

## Chemistry and Physics of “Mahapary Chhat” in Bihar and Ancient Literature



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### Abstract

Chhath (also spelled Chhath Puja or Chhat) is an ancient, regionally central festival of eastern India and Nepal focused on veneration of the Sun (Surya) and Chhathi Maiya. This review synthesizes evidence from ancient literature (epics and Puranas), ethnographic descriptions, recent environmental and food-chemistry studies, and photobiological literature to outline the chemistry and physics underlying the festival's core elements as sun-facing rituals, water-edge practice, and ritual prasad (notably thekua). We show how historical textual references connect to ecological and physico-chemical realities (water quality and management), how food chemistry (Maillard chemistry and frying) governs the organoleptic stability and shelf-life of offering items, and how photobiology explains some putative health effects attributed to sunrise/sunset exposure during ritual. The paper concludes with recommendations for safer, evidence-based practice and priorities for future interdisciplinary research.

## 1. Introduction

Chhath (Chhath Puja, Chhath Parva, Śashti worship) is celebrated chiefly in Bihar, eastern Uttar Pradesh, Jharkhand and Nepal. It centers on strictly observed fasts, ritual bathing at river/pond banks, offerings to the rising and setting Sun, and distribution of prasāda such as thekua. Ancient Indian sources and local puranic/epic traditions associate the festival with episodes from the Rāmāyaṇa and Mahābhārata (Sītā, Kuntī, Draupadī) and with Vedic Sun-hymns (Sūrya Sūktas), situating it in a long history of solar veneration.

From a materials-science and environmental perspective, three features of Chhath merit scientific attention: (1) ritual exposure to solar radiation at dawn/dusk, (2) congregations at open water bodies (water chemistry and public-health implications), and (3) preparation and chemistry of traditional offerings (thermal processing, preservation, and nutritional properties). This paper reviews literature across those domains and relates them to ancient textual motifs.

## 2. Methodology

This is a systematic interdisciplinary literature review. Databases and sources searched (March–September 2025) included Google Scholar, PubMed/PMC, ResearchGate, Scopus-indexed journals, national newspapers, institutional reports, and authoritative reference works (Encyclopaedia Britannica, Sahapedia). Search keywords included combinations of: “Chhath Puja”, “Chhath water quality”, “thekua composition”, “Maillard reaction fried foods”, “sun exposure vitamin D”, “Chhath literature Rigveda Mahabharata Ramayana”, and “Chhath environmental impact”. Inclusion criteria: (a) primary or review literature addressing the festival’s ritual components from physical/chemical or environmental perspectives, (b) food-science analyses of thekua or similar fried jaggery-flour products, (c) water-quality studies of rivers/ponds used during festivals, (d) authoritative textual/epigraphic/ethnographic sources on Chhath’s origin and descriptions.

## 3. Results — Synthesis of Findings

### 3.1 Ancient Literature and Cultural Framing

Mentions of sun-worship and sixth-day observances are present in classical Indian literature. Epics record Sītā and Rāma, and later Kuntī and Draupadī, as associated with vows and rituals that resemble Chhath observance; Puranic material and local tradition anchor Chhath as a distinct Śashti/Surya-votive practice. Vedic hymns to Surya (Sūrya Sūktas) provide the ritual universe from which later local festivals draw symbolic content.

### 3.2 Physics of Sun Worship: Geometry, Irradiance, and Photobiology

Rituals at sunrise and sunset place devotees in shallow solar zenith angles where diffuse and direct irradiance components differ substantially from midday values. From photobiology, controlled short exposures to morning sunlight (UVB in particular) trigger cutaneous conversion of 7-dehydrocholesterol to vitamin D<sub>3</sub>; recommended minimal exposures vary by skin pigmentation, season and latitude but are often on the order of minutes to tens of minutes. Thus, the ritual timing (dawn/dusk) can result in meaningful low-dose UV exposures in some seasons, potentially contributing to vitamin D synthesis and circadian entrainment, while minimizing high-dose UV hazards typical of midday. Benefits depend strongly on season, atmospheric conditions, and latitude.

### 3.3 Chemistry of Prasad: Thekua and Thermal-Processing Reactions

Thekua—a deep-fried or baked wheat/jaggery/ghee product—serves as the archetypal offering. Thermal processing of carbohydrate-rich and protein-containing mixtures produces Maillard reaction products and lipid oxidation products that determine color, aroma, and shelf stability. Studies on similar deep-fried jaggery-based confections show that composition (flour type, moisture), frying temperature and time control Maillard progression, formation of melanoidins and potentially undesirable compounds (e.g., acrylamide under some circumstances). Nutritional/food-technology research on thekua variants reports that formulation adjustments (e.g., substitution with ragi/finger millet, baking instead of frying) can improve nutritional profile and reduce oil uptake while retaining cultural acceptability.

### 3.4 Water Quality and Public Health at Ritual Sites

Festival practices concentrate people at rivers and ponds. Recent physico-chemical surveys of ponds and rivers used for Chhath in Bihar and elsewhere report variable water quality; some locations show acceptable parameters after community cleanup, while highly polluted urban rivers pose acute microbial and chemical hazards to devotees. Field studies and media investigations have documented toxic river conditions that can increase infection risk during mass bathing and ritual immersion. Municipal water management, temporary potable water provision, and pre-festival cleaning dramatically affect exposure risk.

### 3.5 Environmental Footprint and Sustainability Aspects

Local reports and studies often highlight Chhath as comparatively eco-friendly relative to other festivals because rituals occur at natural waters, and offerings are typically plant-based and non-plastic. Nevertheless, environmental impacts (litter, pressure on small water bodies, proliferation of non-biodegradable materials in

urban settings) are documented; ecologically informed governance (clean-ups, biodegradable offerings, restriction of polythene) improves outcomes.

#### 4. Discussion

The ritual triad—sun exposure, water-edge congregation, and processed offering foods—links cultural practice with identifiable physical and chemical processes. Photobiology: Dawn exposure has a plausible mechanistic basis for modest vitamin D production and circadian entrainment, but benefits are conditional on season/latitude and cannot be assumed uniformly. Food chemistry: Thekua's desirable sensory qualities come from Maillard chemistry and frying dynamics. Optimization can retain ritual acceptability while lowering unhealthy lipid uptake or limiting formation of heat-induced contaminants. Water chemistry & public health: Where the water body is clean or recently managed, ritual bathing can be conducted with low risk. Where rivers are polluted, there is elevated risk of illness. Systematic pre-festival water testing, temporary potable outlets, and public health advisories are effective mitigation measures.

#### 5. Recommendations

1. **Public health protocols:** municipal authorities should publish pre-festival water quality results, provide chlorinated drinking-water stations, and install temporary sanitary facilities in high-attendance sites.
2. **Food safety advisories:** promote best frying practices, encourage baking variants or reduced-oil preparation of thekua, and share simple household measures to limit high-temperature contaminants.
3. **Educational outreach:** combine cultural messaging with sun-safety and benefits—advice brief morning exposures rather than prolonged midday sun; acknowledge skin phototype differences.
4. **Research priorities:** (a) systematic analytical chemistry of thekua (Maillard products, acrylamide, lipid oxidation) across preparation methods; (b) coordinated pre/post-festival epidemiological surveillance in high-attendance sites; (c) geo-temporal studies of irradiance during ceremonies to quantify likely photobiological doses.

#### 6. Conclusion

Chhath is a living, ancient festival whose rituals implicate measurable physical and chemical processes. The intersection of Vedic/epic narrative, ritual practice, and modern environmental and food sciences provides fertile ground for interdisciplinary research. Respecting religious practice while applying empirical safeguards and food-technology improvements can enhance devotees' health and the festival's sustainability.

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The authors state that there are no conflicts of interest related to this study.

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