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Reevaluating the halal status of Carmine (E120): A scientific and Islamic legal review

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Abstract

Carmine (E120), a natural red dye extracted from cochineal insects (*Dactylopius coccus*), has long been questioned in its halal status due to its insect origin. Traditional Islamic legal principles generally classify insects as *khabīth* (impure or repugnant), thus non-halal, based on interpretations rooted in scriptural sources and early dietary norms. However, emerging scientific insights, particularly from entomology and food chemistry, challenge the broad generalisation of this classification. Cochineal insects are herbivorous, feed solely on plants, and are cultivated under clean, controlled conditions. Moreover, the process of producing carmine involves *istihālah* (chemical transformation), wherein carminic acid undergoes metal complexation, resulting in altered physical and chemical properties that may meet classical criteria for purification. This study reevaluates carmine through an integrative framework that includes Islamic legal principles (such as *al-aṣl fī al-ashyāʾ al-ibāḥah* and *maqāṣid al-sharīʿah*), scientific evidence, allergenic considerations, and cultural perceptions (*ʿurf*). We argue that carmine can be considered halal when derived from herbivorous cochineal insects and processed with high hygiene and transformative techniques. However, due to potential allergic reactions, transparent labelling remains essential to protect consumers and uphold ethical responsibility. This review encourages refining halal certification practices by integrating jurisprudential tradition with contemporary scientific advancements.

1. Introduction

Pigments play a crucial role in the food industry by enhancing the visual appeal of products, significantly influencing consumer perception and preference. They restore colour lost during processing, ensure uniformity, and sometimes indicate flavour or quality (Hisano, 2016). The sources of these pigments can be broadly categorised into synthetic and natural origins. Synthetic dyes, such as Brillant Blue R and Procion Red MX-5B, are chemically manufactured and widely used due to their vibrant colours and stability. However, concerns over potential health risks associated with artificial dyes have led to a growing interest in natural alternatives (Scotter, 2011; Silva *et al.*, 2022).

Numerous studies have evaluated the efficacy and safety of natural pigments as alternatives to synthetic dyes. For instance, carotenoids from carrots and tomatoes offer yellow to orange hues with antioxidant properties but are sensitive to light and oxygen (Lis & Bartuzi, 2023). Anthocyanins in berries and purple corn yield vibrant reds and purples in acidic conditions but lose stability near neutral pH (Luzardo-Ocampo *et al.*, 2021). Betanin from beets provides a bright red colour but is highly sensitive to heat. These limitations have driven interest in carmine, which provides superior stability across pH and temperature ranges, although its animal origin presents ethical and religious concerns (Rakić *et al.*, 2018; Müller-Maatsch *et al.*, 2018).

Carmine provides a rich, deep red that is difficult to achieve with plant-based dyes. While carmine is not considered toxic, studies have documented rare allergic reactions and hypersensitivity cases, particularly among individuals with pre-existing sensitivities to insect proteins or related compounds (Sadowska *et al.*, 2022; Nakayama *et al.*, 2015). Regulatory toxicology assessments, such as those conducted by the European Food Safety Authority (EFSA) and the U.S. Food and Drug Administration (FDA), classify carmine as Generally Recognised As Safe (GRAS) for both topical and dietary use.

The use of carmine presents complexities regarding its compliance with halal dietary laws, primarily due to its insect origin, which has led to divergent opinions among Islamic scholars and halal certification bodies. This study employs a narrative review methodology, synthesising insights from scientific publications, Islamic jurisprudential sources, and ethical discourse. Rather than adhering to a systematic review protocol, this approach facilitates a multidisciplinary analysis of carmine's halal status by integrating diverse perspectives.

2. Carminic acid to carmine: Extraction, transformation, and applications

Carminic acid, the primary pigment responsible for carmine's vibrant red colour, is extracted from cochineal insects and subsequently transformed into a more stable form for industrial use. This pigment serves a critical defence function for the cochineal, constituting 18% to 30% of the insect's dry weight and offering deterrence against predators. Notably, carminic acid is produced exclusively by female cochineal insects as a chemical defence mechanism. Unlike males, which do not feed and live only briefly after maturing, females remain stationary on cactus pads, making them more vulnerable and dependent on carminic acid for protection (Bustamante-Brito *et al.*, 2019).

Introducing metal ions into the carmine structure significantly alters its solubility profile: it reduces solubility in hot water and alkaline solutions, while the compound remains insoluble in cold water and dilute acids. This phenomenon is rooted in the molecule's polarity. In the absence of metal ions, hydrogen atoms bonded to oxygen in carmine's hydroxyl groups increase the molecule's inherent polarity, enabling it to dissolve readily in highly polar solvents such as water. However, when metal ions replace these hydrogen atoms through coordination bonding, the molecule's overall polarity is reduced, decreasing its solubility in polar solvents.

This chemical transformation directly affects its permissibility under Islamic dietary laws, particularly concerning the legal concept of *istihālah*. The concept refers to converting a prohibited or impure substance into a new, pure form with entirely different properties. In the case of carmine, the transition from an insect-derived acid to a metal-complexed pigment represents a substantial change in chemical structure, function, and identity. According to many Islamic scholars, such a transformation can render an otherwise impure substance permissible if deemed complete. However, this interpretation varies among different schools of thought, with some scholars emphasising the origin of the substance over its end form. Thus, while the chemical evidence strongly supports the notion of a significant transformation, its full legal recognition within Islamic jurisprudence remains a matter of ongoing scholarly debate.

The production of carmine, the metal-complexed pigment, involves a detailed industrial process. This extraction typically begins with harvesting mature female cochineal insects from cactus plants. Subsequently, the insects undergo a drying process, often sun-drying or oven-drying, to significantly reduce their moisture content. The dried insects are then finely ground into powder, from which carminic acid is extracted by boiling it in water or alcohol-based solvents that effectively dissolve the pigment. The resulting solution is then filtered to eliminate any insoluble material. The pigment is precipitated by adjusting the pH or adding specific metal salts, such as aluminium or calcium, to create the final carmine product (Figure 1). Further purification steps, including centrifugation and spray-drying, yield a concentrated dye suitable for various industrial applications (Dapson, 2007).

Once extracted and processed, the resulting carmine pigment exhibits distinct structural differences from its precursor, carminic acid, significantly influencing its thermal resistance and functional applications. Specifically, carmine demonstrates enhanced heat resistance, with a slightly higher degradation point than carminic acid. This property renders carmine particularly advantageous for industrial applications requiring long-lasting pigmentation, notably in the cosmetics, textiles, and food sectors. Moreover, the complexed molecular framework of carmine effectively minimises adverse interactions with light and other environmental factors. This inherent stability broadens its usability, making it suitable for heat-treated and light-exposed products where the greater inherent instability of carminic acid would otherwise be a limiting factor (Liu *et al.*, 2020).

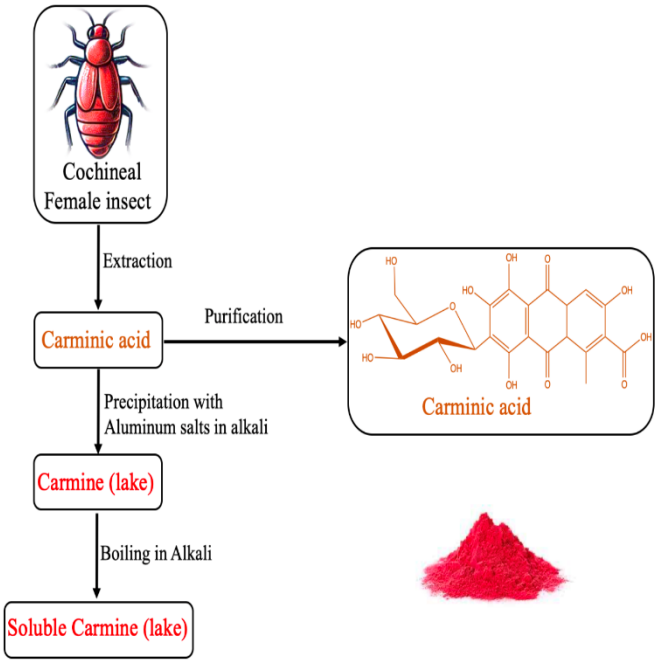

Figure 1: Extraction and purification of carminic acid and carmine.

Beyond its established properties and applications, ongoing scientific advancements are vital to ensure quality control and purity of carminic acid and carmine products. Analytical methodologies, such as spectrophotometric techniques, are vital as they enable the detection of potential adulterants that could compromise the stability and safety of these colourants (Nakayama *et al.*, 2015). Concurrently, driven by increasing consumer preference for natural colourants, substantial research is being conducted into biotechnological methods for synthesising insect-derived pigments. Studies have demonstrated the feasibility of engineering microorganisms to produce carminic acid through biosynthetic pathways, offering a sustainable alternative to traditional insect harvesting while retaining the desirable properties associated with carminic acid and carmine (Gabrielli *et al.*, 2018).

3. Carmine: Properties, perceptions, and concerns

Carmine, a vibrant red pigment, holds significant industrial value across food, cosmetics, and textiles due to its exceptional colour stability and natural origin. A primary advantage lies in its superior resistance to heat, light, and oxidation, which contributes to its durability and ensures consistent colour vibrancy in products, surpassing many synthetic dyes. Furthermore, its non-toxic nature makes it a preferred option for health-conscious consumers, especially given concerns linking some synthetic dyes to adverse health effects.

However, carmine's animal-derived composition is limited, restricting its use in vegetarian, vegan, kosher, and specific Halal diets. This inherent characteristic significantly impedes

accessibility in diverse global markets, particularly as demand for plant-based and ethically sourced ingredients grows. Manufacturers striving for inclusive product formulations often must seek alternative plant-based or synthetic red dyes, despite these often lacking the superior stability characteristic of carmine (Müller-Maatsch *et al.*, 2018). This ongoing challenge underscores the dynamic interplay between traditional ingredient usage and the evolving landscape of consumer ethics and dietary preferences.

In addition to ethical and market limitations, carmine presents significant health-related concerns, particularly regarding its potential allergenicity. Although generally recognised as safe (GRAS) by regulatory bodies like the U.S. Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA), carmine has been associated with allergic reactions in sensitive individuals (EFSA, 2015). These reactions span from mild symptoms, such as skin irritation and urticaria, to more severe conditions like asthma and, in rare instances, anaphylactic shock (Çatlı *et al.*, 2015; Ferrer *et al.*, 2005). This hypersensitivity is primarily believed to be IgE-mediated, triggered by residual insect proteins or carminic acid. Consequently, regulatory agencies have mandated clear labelling: the FDA required carmine declaration on food and cosmetic ingredient labels in 2011, and the European Union similarly mandates its identification under the additive code E120, ensuring consumer awareness and transparency.

Beyond its scientific and regulatory implications, the allergenicity of carmine also carries specific considerations within Islamic dietary law. In this framework, allergenicity does not render a substance *najis* (impure) or inherently non-halal. However, it can inform assessments of *ḍarar* (harm), a crucial principle that may affect permissibility in specific instances, particularly when harm is probable or medically confirmed. Therefore, while allergenicity alone typically does not alter halal classification in most jurisprudential frameworks, it can influence rulings where significant or unavoidable health risks are present.

Despite its favourable safety profile compared to some artificial dyes, specifically its lack of linkage to carcinogenicity and lower association with hyperactivity, carmine's market acceptance is notably complicated by consumer perception. Many individuals exhibit a psychological aversion to insect-derived substances, a sentiment particularly pronounced in cultures where entomophagy is uncommon. This discomfort is especially prevalent among consumers prioritising ethical, religious, or lifestyle-driven dietary restrictions. Such public attitudes significantly influence product marketability, often compelling brands to explore synthetic or plant-based alternatives, even if these options frequently come at the cost of reduced colour stability.

The growing ethical restrictions, allergenic potential, and shifting consumer perceptions have increasingly encouraged the exploration of alternative production methods. Biotechnology represents a promising avenue to replicate carmine's desirable properties while overcoming these limitations. While various other natural red colourants are available, such as beetroot red (betanin) and anthocyanins, they often present their challenges, like susceptibility to heat degradation or pH-dependent colour shifts. In contrast, carminic acid maintains its colour integrity across a broad pH range (4 to 9) and moderate heat exposure, underscoring its unique stability profile for diverse applications (Müller-Maatsch *et al.*, 2018). Despite these diverse sourcing options, its continued use is mainly due to its proven performance. However, the pressing need for ethically sourced and allergy-free alternatives persists as industries and consumers evolve towards greater sustainability and safety (Rakić *et al.*, 2018).

4. Islamic perspectives on carmine

Building on consumer perceptions and ethical considerations, the halal status of carmine (E120) remains a subject of diverse interpretations within Islamic jurisprudence, making a definitive ruling difficult. Traditional Islamic legal thought presents a spectrum of views regarding insect consumption, a divergence that directly impacts carmine's permissibility. The *Hanafi, Shafi'i*, and *Hanbali* schools, representing the majority, generally prohibit insect consumption, classifying them as *khabīth* (filthy) and thus forbidden. This prohibition often stems from interpretations of *Qur'anic* verse 7:157, coupled with the perception of insects as inherently disagreeable. In contrast, the *Maliki* school adopts a more inclusive position, holding that insects can be permissible if they are killed adequately with the intent of consumption, akin to ritual slaughter (Campana *et al.*, 2015). Within *Maliki* jurisprudence, non-poisonous insects are not automatically non-halal; for instance, while locusts are explicitly permitted by authentic *Hadith* (Faridah, 2019), other insects, such as grasshoppers, silkworms, and bees, may also be deemed permissible if prepared correctly, such as through drying or boiling to be used medically (Soumena, 2024) (Table 1). These divergent views ultimately reflect broader differences in interpreting fundamental concepts like purity (*ṭahārah*) and harm (*ḍarar*) across the various Islamic legal schools.

This classical divergence in jurisprudential thought regarding insect consumption is mirrored in contemporary Islamic rulings concerning carmine. Many modern scholars issue fatwas declaring carmine non-halal due to its insect origin. For instance, a *fatwa* from Islamweb explicitly prohibits carmine extracted from dried cochineal beetles, citing not only the insect origin but also the classification of these insects as *maytah* (unslaughtered carrion) and the potential involvement of alcohol in the extraction process (Aidulsyah & Mizuno, 2020). Similarly, a *Hanafi fatwa* from Trinidad's *Darul Uloom* deems carmine impermissible, asserting that "the consumption of insects is not permitted" and falls within the *Qur'anic* prohibition of filthy substances, extending this to carmine-based lipstick due to ingestion risk (Vanany *et al.*, 2019). Conversely, some scholars argue that carmine's chemical processing constitutes *istihālah*. The Jordanian General *Iftaa* Department, while acknowledging the dominant prohibitory view on insect consumption, emphasised that a complete transformation of a substance's nature can render it pure and permissible (Table 2). Accordingly, they ruled that E120 undergoes a substantial chemical change and may be considered halal, provided no suitable alternatives exist, and it is used in necessary amounts. It poses no harm to consumers (Pabbajah *et al.*, 2022).

For *istihālah* to be considered valid in classical Islamic jurisprudence, the original characteristics—such as taste, smell, colour, and physical form—must be entirely lost and replaced by new, permissible qualities. The canonical analogy for this principle is the transformation of wine into vinegar, which becomes lawful once its intoxicating properties are completely altered.

Table 1. Classical Islamic schools of thought on insects

Islamic School / Scholar	General Ruling on Insects	Basis of Classification
***Hanafi* School**	Non-halal: Only locusts are halal	Insects are classified as *khabith* unless explicitly permitted in Islamic texts. The consumption of locusts is allowed based on authenticated *Hadith*, but other insects are prohibited due to their association with filth and impurity.
***Shafi'i* School**	Non-halal: Locusts and certain water insects (e.g., small shrimp, sea insects)	Insects are considered not *tayyib* (pure) and are therefore non-halal unless specifically mentioned in Islamic texts as permissible. Water insects that are not repulsive and do not pose harm are sometimes permitted.
***Maliki* School**	Generally halal: No explicit exceptions needed	Anything not explicitly prohibited in Islamic texts is considered halal by default. The *Maliki* school adopts a more lenient approach, allowing the consumption of all insects unless evidence from the *Qur'an* or *Hadith* indicates impurity or harm.
***Hanbali* School**	Non-halal: Only locusts are halal	Similar to the *Hanafi* stance, insects are deemed impure (*khabith*) except for locusts, which are mentioned in *Hadith* as an exception.

Table 2: Summary of *Fatwa* positions on the halal status of carmine (E120)

Fatwa Body	Country	Position	Basis of Ruling
Jordan General Iftaa Department	Jordan	Halal	Complete transformation (*istihālah*)
IFANCA	USA	Cautiously halal	Under strict conditions
Dar al-Ifta Egypt	Egypt	*Haram*	Source is insect

In the specific case of carmine, scholars remain divided: some contend that the metal complexation of carminic acid fulfils the criteria of *istihālah*. In contrast, others maintain that residual traces linked to the insect's origin prevent complete purification and thus preserve its impure status.

This classical divergence in jurisprudential thought regarding insect consumption is mirrored in contemporary Islamic rulings concerning carmine. The halal status of carmine (E120) is, therefore, not uniformly recognised worldwide, with various national halal authorities and certifiers issuing conflicting guidelines. Notably, several prominent certifiers in Muslim-majority countries have, in recent years, ruled carmine to be permissible, often diverging from earlier stances (Qodir *et al.*, 2023). For instance, the Indonesian Council of Ulama (MUI) issued *Fatwa* No. 33/2011, declaring carmine-derived food and drink colourings halal, reasoning that cochineal insects—likened to grasshoppers—lack a larval stage and flowing blood, live on clean plants, and are not explicitly forbidden in *Qur'an* or *Hadith*, provided the dye is beneficial and non-harmful. Similarly, Malaysia's National *Fatwa* Committee, after revisiting the issue in 2012, allowed cochineal-based colouring, citing the insects' non-toxicity, human benefit, and the classical legal principle that carcasses of insects without flowing blood are ritually pure, and thus not considered *najis* (impure) (Syahnan *et al.*, 2021). Consequently, products containing E120 can be halal-certified in Malaysia under JAKIM's standards, with both MUI and JAKIM's approvals holding significant global influence (Setiawan, 2022; Sultoni *et al.*, 2021). In contrast, other halal standard bodies, such as the Standards and Metrology Institute for Islamic Countries (SMIIC), which includes Turkey and other OIC members, classify carmine as non-halal for edible use (Mufid & Muhammad, 2023). This position aligns with more conservative scholarly views, exemplified by countries like Iran, which also tend to regard carmine as impermissible (Moslemi, 2024; Rohim *et al.*, 2023) (Table 3).

5. Halal status of insects in general and Cochineal in particular

Traditional Islamic *Fiqh* has typically categorised insects under *khabīth*—a *Qur'anic* term signifying impurity, filth, or harm (*Surah Al-Aʿrāf*: 157)—thereby rendering them non-halal (Faridah, 2019). This ruling is rooted in the concept of *fiṭrah* (natural disposition), favouring *tayyib* (pure, wholesome) foods and avoiding what is repugnant or harmful. The dichotomy of *tayyib–khabīth* underpins Islamic dietary law: *Tayyib* includes the intrinsic purity of a substance and its production process, requiring maximum hygiene and minimal contamination. Conversely, *khabīth* refers to substances that are either biologically impure, processed under unhygienic conditions, or naturally harmful. This classification extends to animal products: meat from herbivorous animals (plant-eaters) is halal, while carnivorous or waste-eating animals are deemed *khabīth* and thus *haram*.

Modern entomological research, however, offers a more detailed classification of insects based on their dietary behaviour. Scavenging insects—such as flies and cockroaches—consume waste, blood, or filth, strengthening their association with impurity and disease (Rainford & Mayhew, 2015). In contrast, herbivorous insects like cochineals (*Dactylopius coccus*) feed exclusively on *Opuntia* cactus, a clean, plant-based food source (Kelly *et al.*, 2022). This dietary distinction is crucial: Insects that consume *tayyib* substances and are raised in hygienic environments no longer fit the classical *khabīth* definition. Cochineals fall within this category, aligning them more with the *tayyib* side of the spectrum (Neves *et al.*, 2010; Kuchenbecker & Fagundes, 2018).

The permissibility of carmine is further supported by the principle of *istihālah* (transformation). During processing, cochineal-derived carminic acid undergoes chemical transformation through metal complexation—most commonly with aluminium salts—resulting in carmine (Liu *et al.*, 2020). This transformation alters the substance's solubility, acidity, and chemical identity, aligning with the juristic concept of *istihālah kāmila* (complete

Table 3. Contemporary halal authorities and scientific perspectives on insects and carmine

Authority / Perspective	Position	Basis of Classification
Contemporary Halal Certification Authorities	Varies by country and scholar: Some allow carmine from cochineal, others reject it	Some scholars and halal certifiers differentiate between herbivorous and scavenging insects. Cochineal insects feed on cacti (*tayyib* food), unlike flies or cockroaches that thrive in filth. Some halal authorities, such as Indonesia's MUI, accept carmine as halal due to its purification process, while others, such as Turkey's SMIIC, reject it due to its insect origin.
Modern Scientific & Logical Approach to Insect Classification	Requires differentiation: Herbivorous vs. scavenging/blood-feeding insects	Advancements in entomology suggest that not all insects should be classified under the same ruling. Insects feeding on impure substances (e.g., decaying matter, blood, feces) are more likely to be considered *khabith*, while those feeding on clean, plant-based diets (e.g., cochineal, grasshoppers, silkworms) do not fit the classical definition of impurity and are more likely to be considered *tayyib*.

transformation), which removes the impurity and permits the end product to precipitate in high purity (Pabbajah *et al.*, 2022). Classical scholars use the wine-to-vinegar transformation as a canonical example of *istihālah*. Following this model, the transformation of carminic acid into carmine can be viewed as purifying, especially when the final product no longer retains the properties of the original impure substance.

Importantly, Islamic rulings also consider cultural norms (*ʿurf*) and societal perception when textual evidence is absent or ambiguous. While some societies find insect-based products repulsive, others accept them as sustainable food sources. Islamic law accommodates such variance: the Prophet Muhammad refrained from eating roasted lizard (*ḍabb*) but clarified it was not forbidden—he did not prefer it (Ṣaḥīḥ al-Bukhārī, *Hadith* no. 5537). This example underscores that aversion does not equal prohibition and highlights the legal principle that abstention due to custom does not amount to a ruling of *haram*. In the context of carmine, cultural discomfort should not override religious principles or scientific evidence. Instead, rulings should reflect the higher objectives of Islamic law (*Maqāṣid al-Sharīʿah*), such as preserving health, ensuring purity, and upholding dignity (Rahim, 2018).

From a legal standpoint, the principle of *al-aṣl fī al-ashyāʾ al-ibāḥah*—that the default status of things is permissibility unless proven otherwise—further strengthens the case for carmine. Regulatory bodies such as the FDA and EFSA classify carmine as Generally Recognised as Safe (GRAS), while it may cause allergic reactions in some individuals (Sadowska *et al.*, 2022). Allergenicity alone does not render a product non-halal, just as locusts are permitted despite potential allergic effects. Transparent labelling allows consumers to avoid the ingredient when needed, respecting individual sensitivities without enforcing a generalised religious restriction on all users.

In light of these converging scientific, legal, and ethical considerations, carmine—when derived from herbivorous cochineal insects and processed under hygienic and chemically transformative conditions—qualifies as halal according to both classical principles and contemporary fatwa bodies, with the additional requirement of transparent labelling to uphold consumer trust.

6. Conclusion

The halal status of carmine should not be determined solely based on its origin from insects. From which carmine is derived, cochineal insects (*D. coccus*) are herbivorous—feeding exclusively on plant matter such as cactus—and are typically cultivated in clean, controlled environments. This plant-based diet distinguishes them from scavenging or blood-feeding insects traditionally associated with impurity (*khabīth*) in Islamic law. Moreover, the production of carmine involves a substantial chemical transformation through metal complexation of carminic acid, fulfilling the classical jurisprudential concept of *istihālah kāmila* (complete transformation), which permits the transition from impure to pure substances. Given the absence of explicit scriptural prohibition, the application of the Islamic legal maxim *al-aṣl fī al-ashyāʾ al-ibāḥah* (the default ruling on things is permissibility), and alignment with the higher objectives of *Sharīʾah* (*Maqāṣid al-Sharīʿah*), carmine—when derived from herbivorous insects and processed under hygienic and transformative conditions—qualifies as halal. Transparent labelling remains essential to accommodate consumer sensitivities and potential allergenic concerns. Going forward, greater scholarly collaboration is needed to develop unified, evidence-based halal standards incorporating contemporary scientific understanding and legal reasoning, particularly for ingredients derived from unconventional sources.

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