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UV Intermittent Sterilization for Controlling *Aspergillus spp* Dissemination and Preventing Aflatoxin Dairy Contamination: The Quantum Gravity Linearity Shifting Collapse Mechanisms Underline Bio-Systems and the Definition of Entropy-Stabilized Barycenter (EB)

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Abstract
Aflatoxin contamination caused by filamentous fungi such as Aspergillus spp. remains a persistent global food safety challenge, particularly in grain and animal feeding storage and agricultural supply chains. Building upon an earlier environmental control patent framework and subsequent ultraviolet (UV) sterilization practices standardized during the COVID-19 period, we developed and formalized a UV intermittent sterilization strategy for low-cost control of filamentous fungal dissemination. This approach has been incorporated into a patent design aimed at agricultural implementation.

Unlike continuous UV exposure, the UV intermittent method is structured to enhance operational efficiency while minimizing material degradation and preserving implementation feasibility. We propose that, beyond conventional DNA damage mechanisms, the quantized intermittent UV irradiation can make use of the biological |EP⟩ wound healing compensation mechanism to destabilize the Entropy-Stabilized Barycenter (EB). EB represents a measurable gravitational |EP⟩ linearity shifting coherence associated with bio-system surface tension regions. Quantized destabilization of EB undermines fungal dissemination capacity to suppress aflatoxin contamination.

Different from conventional gravitational mass centers derived from static mass distributions, bio-system EB may arise from dynamic EntropyFlows. Preliminary Cavendish mutation and FHD observations suggest quantum gravity amplification far beyond traditional static mass-center expectations, with direct associations to biological vitality and aging.

Keywords: Aflatoxin, UV Intermittent Sterilization, Entropy-Stabilized Barycenter (EB), Microscopic Symmetric Spin, Bohr Spooky Collapse, Dead Eigenstate, Bio-Active Eigenstate, Macrocosmic Asymmetric Spin, Alive Linearity Shifting Collapse

1. Introduction of the Quantized UV Intermittent Sterilization Patent

1.1 Patent Title： UV intermittent method and Indoor sprout production technology as a replacement for hay and silage in wintertime dairy and livestock feeding systems for the elimination of aflatoxin contamination.

1.2 Patent Background and food Safety Issue, it Intends to Address

1.2.1 Aflatoxin as a Major Threat to Public Health and Population Longevity

Aflatoxins (AFT) are highly toxic mycotoxins commonly produced by several species of the genus *Aspergillus, including A. flavus, A. parasiticus, and A. nomius* [1]. Aflatoxins widely contaminate cereals, nuts, oilseeds, and their processed products. Major staple crops such as maize, peanuts, and rice are among the primary carriers of AFT contamination [2]. In addition, aflatoxins have also been detected in spices, coffee, tea, and dairy products. Aflatoxins are considered among the most potent naturally occurring carcinogens known to date. Their decomposition temperature ranges from approximately **237–306 °C,** which makes them extremely difficult to eliminate through conventional food/feed processing methods [1].

At least **14 types of aflatoxins** have been identified in nature. The most important include **B1, B2, G1, and G2,** among which **aflatoxin B1 (AFB1)** exhibits the highest toxicity [2]. Other metabolites such as **M1 and M2** were first discovered in the milk of dairy cows fed mold-contaminated grains. These compounds are metabolic products generated in the liver of animals exposed to other aflatoxins and have also been observed in fermentation media containing parasitic Aspergillus species.

Currently, approximately **120 countries worldwide** have established regulatory safety standards for aflatoxin levels in food and feed products [2]. For example, the commonly accepted safety **limit for liquid milk is around 0.5 ppb (parts per billion), while feed materials are typically regulated below 20** ppb. It is estimated that **60–80% of global grain crops are affected by aflatoxin contamination,** potentially impacting the health of **approximately 4.5 billion people worldwide** [1]. However, due to the difficulty of controlling AFT contamination, current food safety standards in many regions still emphasize microbial indicators such as viable bacterial counts (e.g., *Escherichia coli, Salmonella spp., etc.*), whereas regulatory enforcement for mycotoxins like aflatoxin remains comparatively less stringent. One important reason is that bacterial contamination can often be corrected through improvements in quality control and sanitation procedures. In contrast, strict enforcement of aflatoxin limits would result in extremely high product recall rates, affecting not only developing countries but also many food industries in developed nations. Such recalls could exceed the tolerance capacity of the market and are often difficult to resolve through conventional quality control measures. Therefore, despite the fact that the health risk posed by aflatoxins is much more threatening to human health than that of published bacterial indicators, the practical difficulty of controlling AFT contamination has led to relatively weaker enforcement of aflatoxin standards compared with microbial standards. Common regulatory limits for aflatoxin contamination in food products are summarized as follows:

Food Category	Total Aflatoxin Limit (AFB1 + AFB2 + AFG1 + AFG2)
Peanuts, maize (corn)	≤15 ppb
Rice, sorghum, legumes, wheat and nuts	≤10 ppb
Edible oils and fats	≤10 ppb
Fresh milk	≤0.5 ppb (AFM_1)
Milk powder	≤5.0 ppb (AFM_1)
Other food products	≤10 ppb
Animal feed (all types)	strictly < 20ppb

Table 1: Representative Regulatory Limits for Aflatoxin Contamination in Major Food and Feed

It should be particularly noted that the strict regulatory limit of **below 0.5 ppb for liquid milk** is not only due to the classification of aflatoxins as **Group I carcinogens,** but also because of their strong association with **childhood developmental disorders, congenital defects, and growth retardation** [2]. Direct health risks to humans include **hepatocellular carcinoma caused by chronic exposure, immunosuppression, congenital birth defects, and delayed childhood development.** In developing countries, health problems in children associated with aflatoxin-contaminated dairy products are significantly more severe than in developed nations [2].

It has been estimated that populations consuming milk containing excessive aflatoxin levels over long periods may experience **an average reduction in life expectancy of at least ten years.** This reduction in lifespan is largely attributable to two major factors. First, aflatoxin exposure during infancy and early childhood severely affects growth and developmental processes. Second,

many age-related diseases—including **cancer, renal failure, diabetes, and atherosclerosis**—tend to appear **5–10 years earlier at the population level.** Modern medicine currently has very limited capacity to cure these diseases; most treatments focus primarily on delaying progression rather than achieving full recovery. Clinical outcomes are often measured using **five-year survival rates.** Therefore, the earlier onset of these diseases at the population level can have a substantial impact on average life expectancy. Early-life exposure also increases long-term health vulnerability, thereby contributing to the earlier emergence of chronic diseases later in life.

Some people advocate vegetarian diets as beneficial for longevity. However, it should be recognized that the health benefits of plant-based diets can only be realized **after aflatoxin contamination has been effectively controlled.** In reality, plant-based foods are often **several times more likely to be contaminated with aflatoxins than animal- derived foods.** Consequently, consuming plant foods contaminated with aflatoxins may undermine the intended health benefits and can paradoxically increase long-term health risks.

1.2.2 Fungal Sources of Aflatoxin Contamination in Feed and Key Control Factors in Large-Scale Production

Molds, primarily filamentous fungi belonging to the genera Aspergillus spp. are the dominant sources of aflatoxin (AFT) contamination. Soil Petri dish isolation methods typically show that 70–80% of fungal colonies recovered from soil belong to Aspergillus spp. and Penicillium spp. This distribution indicates their strong competitive advantage over other fungi when spores are present at similar densities and grown under identical nutrient and environmental conditions. This ecological dominance is closely associated with their high metabolic activity, rapid growth rates, strong sporulation capacity, and broad adaptability to diverse environmental conditions [3]. These characteristics also explain the widespread occurrence of aflatoxin contamination in food systems.

In feed, grain, and seed storage environments, fungal contamination primarily originates from soil sources [4]. During mold development, humidity plays a more critical role than temperature in controlling contamination [5]. Under high humidity conditions (>76% relative humidity), fungal growth and germination become rapid and difficult to control, even when temperatures deviate from optimal ranges [5,6]. As a result, traditional mold control in hay-based feed systems relies heavily on moisture management [8]. Storage structures equipped with waterproof roofing, concrete flooring, or protective bedding materials can significantly reduce contamination risk [8]. However, such conditions are often unavailable to many farms, particularly in regions with frequent rainfall, leading to high contamination rates.

Silage systems attempt to suppress fungal growth through anaerobic fermentation, which requires the establishment of sufficiently low-oxygen or anaerobic microbial ecosystems [9]. If these conditions are not properly maintained, fungal toxin contamination can rapidly increase [9]. In addition, silage storage requires a carefully balanced moisture level— neither too dry nor too wet—which in practice can be even more difficult to control than hay systems. Due to these technical constraints, suboptimal storage conditions for both hay and silage are widespread in large-scale agricultural production globally.

1.2.3 Aflatoxin (AFT) Contamination in Dairy Products Primarily Originates from the Following Sources

• Contamination from hay and Silage Feed

During winter, when fresh forage is insufficient, livestock feeding systems worldwide rely heavily on a combination of hay, silage (predominantly corn stalks), and concentrated feed. These materials are highly susceptible to moisture exposure during storage and use, leading to mold growth and subsequent AFT contamination. In winter conditions, such contamination accounts for more than 70% of total AFT occurrence.

• Inadequate storage Conditions

In addition to hay and silage, winter feed typically includes concentrated feed components, mainly grains such as corn. These materials are often stored under suboptimal conditions and are equally prone to moisture-induced mold contamination.

Field observations conducted across more than thirty farms in the United States and Canada indicate that feed storage facilities are commonly constructed from wood. In most cases, visible mold growth can be observed within these storage areas. Such facilities themselves act as persistent sources of fungal contamination. Farm workers generally show little concern for visible mold, largely due to regulatory practices.

Although regulatory agencies such as FDA, USDA, CFIA, AAFC, and OMAFRA recognize the strong role of humidity in accelerating mold contamination, existing regulations primarily emphasize the absence of visible standing water. In contrast, management of visible mold contamination or previously contaminated storage environments is often insufficiently enforced. In practice, only a very small proportion of inspectors require cleaning before continued agricultural use, largely because the renovation of the space and further control of temperature and moisture are beyond the financial capacity of most farmers. As a result, both inspectors and farm operators lack sufficient awareness regarding the risks posed by mold contamination and effective methods for its elimination. The situation is even more severe in China, where small-scale farms often operate under rudimentary storage conditions, with limited control not only of mold but even of indoor stagnant water accumulation.

It is important to recognize that storage environments with visible mold colonies contain extremely high densities of fungal spores. Even after routine chemical disinfection, spore density is largely unchanged. Once high humidity conditions are available,

contamination can rapidly expand and become difficult to control. Without the implementation of effective low-cost UV intermittent sterilization method proposed in this patent—storage facilities themselves remain major sources of fungal contamination. Due to multiple practical constraints, regulatory oversight of mold contamination has, in many cases, become functionally ineffective.

These observations indicate that inadequate feed storage conditions leading to mold contamination are a widespread global issue. While early-stage regulatory personnel may have recognized the risks associated with AFT contamination, the high cost of improving humidity control in storage environments has led to the adoption of compromised practices, such as superficial cleaning followed by continued use. Over time, this approach has been perpetuated through successive generations of inspectors, resulting in a systemic underestimation of AFT-related risks.

Consequently, the majority of licensed agricultural storage inspectors in China, the United States, and Canada lack effective methodologies for controlling fungal spore density in feed storage environments to safe levels. This highlights the urgent societal need for the present invention and its potential impact on food safety and public health.

Aflatoxin is colorless, odorless, and highly thermally stable. Neither milk producers nor consumers can detect its presence through sensory evaluation, leading to prolonged exposure without awareness. It is estimated that long-term consumption of AFT-contaminated dairy products may reduce average lifespan by approximately 10 years. We should realize that while contamination in solid foods primarily affects adults, AFT contamination in dairy products directly and severely impacts infants and young children, posing a significant threat to **population health and life expectancy.**

1.3 Patent Implementation and Innovation

Origin, Operational Method, and Application Scenarios of UV Intermittent Sterilization Technology

1) Origin of the Method

The UV intermittent sterilization method originates from the practical implementation of US patents US2022/0314041 A1 and US11554186 B1. It was initially developed for controlling airborne transmission of COVID-19 and demonstrated strong effectiveness in inactivating infectious pathogens in indoor environments. This method employs intermittent UV irradiation (typically every other day) to achieve efficient pathogen inactivation. The associated device has obtained Health Canada interim authorization as a Class II medical device for COVID-19 (License ID. 321287). In its initial clinical applications, the system focused primarily on indoor environments without explicitly considering humidity conditions, as SARS-CoV-2 transmission is largely independent of humidity [7]. In natural environments, virus viability typically persists for only a few days, and in indoor settings with repeated human presence, infectious persistence is generally limited to approximately two weeks, with transmission primarily dependent on host density.

In contrast, fungal spores exhibit fundamentally different behavior. Their resistance to adverse environmental conditions is significantly higher than that of vegetative fungal cells. Fungal spores can survive for 3–5 years under harsh conditions and rapidly germinate once exposed to suitable humidity and nutrient availability. Consequently, on any nutrient-containing substrate, visible mold growth can develop within hours to one or two days under moist conditions. Due to these characteristics, extending UV intermittent sterilization into agricultural applications for fungal contamination control requires careful consideration of high- humidity environments. The resulting system provides a low-cost and highly efficient solution for controlling fungal contamination in indoor or semi-enclosed spaces, including grain storage facilities, seed warehouses, livestock housing, food processing areas, and environments involving human–animal airborne transmission risks (e.g., H1N1).

2) Operational Method and Mechanism of UV Intermittent Sterilization

The method employs intermittent UV irradiation, typically for 30 minutes every other day, for sterilization or surface disinfection. Exposure duration can be extended (e.g., up to 3 hours or twice daily), and the system can be automated for unattended operation, thereby reducing labor costs. The mechanism is based on irradiation with UVC wavelengths (253.7 nm and 185 nm), which disrupt microbial DNA structures, rendering microorganisms incapable of replication and survival. The first irradiation effectively eliminates the majority of vegetative microbial cells. However, a small fraction of microorganisms—such as fungal spores or bacterial endospores—may survive initial exposure. Although not immediately killed, their DNA is severely damaged, and successful repair requires significant nutrient availability, favorable humidity conditions, and time for DNA repair processes. During this recovery phase, their growth and reproductive capacity are substantially impaired.

Subsequent intermittent irradiation further targets these weakened survivors. Because the remaining microbial population is both reduced and physiologically compromised, the effectiveness of follow-up irradiation is significantly enhanced, ultimately leading to complete eradication.

3) Comparison with Traditional Intermittent Sterilization Methods

Tyndallization represents the classical intermittent sterilization method, proposed by the British scientist John Tyndall in the 19th century [10]. Due to its extensive application in microbiological training by Robert Koch, it is also referred to as the Koch steam sterilization method in some literature. This method, widely used in laboratory research and specific industrial settings, targets

heat-resistant bacterial spores through repeated cycles of heating (typically at 100°C) followed by cooling. During the intervals, spores germinate into vegetative cells, which are then eliminated in subsequent heating cycles.

The UV intermittent sterilization method proposed in this invention shares a similar conceptual framework with classical Tyndallization. Both methods rely on repeated, time-separated interventions that exploit biological vulnerabilities during recovery phases. Tyndallization targets the transition of spores into vegetative cells, whereas UV intermittent sterilization exploits the vulnerability of microorganisms during DNA repair following irradiation-induced damage. Both approaches embody the core principle of inducing residual cells to enter a vulnerable state and subsequently eliminating them through repeated treatments. However, traditional Tyndallization is limited to small- scale applications or high-value products due to the requirement for sustained high-temperature treatment (100°C), which is energy- intensive and difficult to scale. In contrast, UV intermittent sterilization enables large-scale application, particularly for airborne microbial control, where it represents one of the most effective available methods. Its advantages include high cost- efficiency, absence of chemical residues, no environmental contamination, and no induction of microbial resistance, making it highly suitable for widespread, low-cost deployment.

1.3.1 UV Intermittent Sterilization Safety Controller (AI-Integrated for OTC Deployment)

UV intermittent sterilization is a highly efficient, low-cost method for controlling mold contamination that leaves no chemical residues and does not contribute to antimicrobial resistance. However, unlike conventional disinfection and sterilization methods, this patent employs UV intermittent sterilization for a specific purpose: suppressing mold growth in indoor spaces to prevent the formation of visible mold patches. This unique application for indoor mold control introduces a critical safety concern. When people are present in the space, 254 nm and 185 nm UV radiations must not directly expose their bare skin or eyes. This necessitates a safety controller that automatically detects the presence of people within a 3–5-meter range, halting UV radiation when someone is nearby and resuming irradiation after the person has left for a specified period (given that intermittent UV sterilization requires only 30 minutes of UVC exposure per day, and slight timing adjustments have minimal impact on sterilization efficacy). During the COVID-19 pandemic, we obtained an interim order Class II medical device ID (321287) from Health Canada. However, as a Class II medical device, its use was restricted to prescription-based applications by doctors and nurses in medical facilities, prohibiting direct public use. By incorporating this safety controller, which can replace the need for medical professionals to ensure safe operation, and with its AI integration capability—offering even greater control efficiency than doctors or nurses—the public can now use it over-the-counter for indoor mold control. The controller operates using radar or infrared sensing, is compactly located near the lamp head, and functions automatically. Through multiple rounds of refinement, this safety controller now achieves stable, high-quality performance for up to 100,000 cycles, effectively replacing the role of medical personnel while significantly enhancing user safety, thereby enabling safe over- the-counter public use.

1.3.2 Innovations in Indoor Sprout and Shoot Production Technology

Sprouts and shoots are produced by growing seeds in a controlled indoor environment where temperature, humidity, and light are regulated, allowing for the rapid production of highly nutritious sprouts and shoots. These plants do not come into contact with soil. Generally, “sprouts” refer to those grown without light, appearing pale, while “shoots” are grown with light, appearing green. Their production cycle is short, ranging from 7 to 14 days, allowing for on-demand cultivation without the need for long-term storage, and enabling indoor factory-scale production. They are highly nutritious, rich in proteins, vitamins, and minerals. By applying our UV intermittent sterilization technology throughout seed storage and the sprout/shoot production process, and given that sprouts and shoots do not come into contact with soil, the risk of mold contamination is very low. Additionally, mold-contaminated seeds fail to germinate, and the germination process itself naturally eliminates contaminated seeds. Even if minor contamination occurs during production (typically only 5–10% contamination in finished products, even when using highly contaminated seeds), it can be easily identified and removed during production. As a result, the likelihood of mold contamination in sprouts and shoots is nearly zero. Moreover, the short production cycle eliminates the need for storage, further reducing contamination risks. This process whereby mold contaminations are effectively eliminated during sprout and shoot production is collectively referred to as the “self-purification” effect against mold contamination. Although indoor factory-based sprout and shoot production processes and equipment have been developed for years, with mature quality control techniques that leverage environmental control, soilless cultivation, and rapid production to deliver high-quality, mold-free products—some processes even achieving automation—the innovative application of this “self-purification” effect to prevent aflatoxin (AFT) contamination in dairy cattle winter feed represents a novel approach. This has not been previously explored and constitutes an innovation of this patent under the concept of “self-purification in indoor sprout and shoot production.”

1.3.3 Innovation in Grow Fresh Food Preservation [11] Technology: An Objective Gravitational Measure of Vegetable Freshness

Traditional fresh vegetable preservation primarily relies on post-harvest low-temperature storage and packaging techniques. Common methods include the use of packaging or modified atmosphere packaging (MAP), storing vegetables at low temperatures (4 °C), and employing nitrogen flushing or adjusting oxygen and carbon dioxide ratios to inhibit microbial growth and plant respiration, etc. Additionally, some products incorporate pre-

cooling, cleaning and disinfection, and cold chain logistics to extend shelf life. However, a common characteristic of these methods is that vegetables, after harvesting, cleaning, and packaging, are detached from their original non-rotational entropy growth system, and the tissues gradually enter a state of senescence. Even with various technological interventions, the best-before shelf life of preserved vegetables rarely exceeds two weeks, requiring continuous cold chain transportation and incurring relatively high packaging costs.

The Grow Fresh preservation system proposes a different approach: preserving freshness by maintaining plants in a continuous growth state. In this system, vegetables are not provided to consumers or users in a preserved form after harvest but rather as actively growing plants, thereby significantly extending their preservation period while reducing reliance on low-temperature storage and complex packaging systems, leading to lower energy and material costs. The term "Grow Fresh" itself signifies preservation in a growing state.

In previous experiments, we compared the physical entropy stability of mung bean and soybean seeds under different conditions. The results showed that bean sprouts germinated for 24 and 48 hours exhibited significantly higher *FHD* (failing height difference) measurements compared to the corresponding raw seeds [12]. These findings indicate that during germination, the structural stability of the system is markedly enhanced. In other words, plant systems in a growth phase possess a higher entropy stabilized barycenter (EB). Consequently, in practical GrowFresh applications, freshness is no longer assessed through subjective visual evaluations but can be objectively determined by irrotational entropy stability. We therefore term this preservation method "gravity irrotational entropy freshness preservation or detection technology," representing another innovation of this patent. Dairy cows fed with this preserved forage produce milk exhibiting notable bifidogenic properties, marketed under the Bifidogen trademark. This suggests that the EB present in the forage is transferred to the dairy products, endowing them with superior entropic stability compared to conventional dairy products.

1.3.4 Innovation in Indoor Sprout and Shoot Boxing Technology

Boxing technology refers to the practice of sowing and harvesting sprouts and shoots in the same container. This represents one of the technological innovations in large-scale production that prevent aflatoxin (AFT) contamination and improve quality. It prevents contaminated sprouts from affecting healthy products and facilitates the removal of substandard items. This approach is also enabling automated control in large-scale production while reducing labor and material costs. This technology has never been present in any sprout and shoots production systems, therefore constitutes an innovation of this patent.

1.3.5 Innovation in Winter Dairy Cattle Feed Storage Space

In the winter feed supply for dairy cattle, traditional hay and silage require significant storage space. By adopting our patented technology, only seeds need to be stored during winter, substantially addressing the long-standing challenges of large storage space requirements, high mold contamination risks, and elevated production costs associated with winter dairy feed. Sprout and shoot technology requires only seed storage, with one 1 kg of seeds yielding 7-10 kg of sprouts and shoots. It also enables dynamic production: cultivating and feeding simultaneously, eliminating the need to store feed for the entire winter season at once, thereby further reducing spatial pressure. In contrast, traditional hay and silage must be prepared in quantities sufficient for the entire winter, with production cycles spanning several months, making dynamic production difficult to achieve. These combined factors are collectively referred to as the "innovation in winter dairy cattle feed storage space," offering significant economic value and food safety advantages, summarized in the table 2 below:

Factor	Sprout/Shoot Technology	Hay	Silage
Storage Space	Low space requirement; dynamic production	High space requirement; one time bulk storage	High space requirement; one time bulk storage
Production Cost & Specialized Supply	Seeds can be produced through specialized off farm division of labor; low scale based costs; low economic and labor costs	High labor and facility costs; difficult to achieve specialized division of labor; hard to automate	High facility and management costs; difficult to achieve specialized division of labor; hard to automate
Mold Control Effectiveness	Self purification + intermittent UV; no contamination even under high humidity	Dependent on weather and humidity control; high contamination risk	Relies on sealed fermentation and moderate humidity; high contamination risk
AFT Contamination	Completely free from mold contamination	Widespread contamination	Widespread contamination
Additive Contamination	No additives required; contamination free	No additives	Chemical additives pose risks of secondary contamination and antimicrobial resistance; microbial additives are costly with limited efficacy

Production Cycle	1 2 weeks; short cycle; seeds can be stored dynamically	Several months; long cycle; cannot be produced dynamically	Several months; long cycle; cannot be produced dynamically
Technical Complexity	Low; easy to automate	Moderate; requires humidity control	High; requires strict sealing and fermentation management
Suitable Scale	Suitable for both large scale and small scale production	Prone to issues in large scale production	Prone to issues in large scale production
Land Utilization	Reduces footprint on dairy farms; frees up land for raising more cattle	Requires land on dairy farms for production; cannot free up land	Requires land on dairy farms for production; cannot free up land
Supplier Distance	Seeds can be transported cost effectively over long distances	Purchased hay is limited to local sources due to transportation costs	Purchased silage is limited to local sources due to transportation costs

Table 2: Comparative Advantages of Sprout/Shoot Technology vs. Traditional Hay and Silage in Winter Dairy Cattle Feed Storage Space

2. Materials and Methods

Validation Experiments on the Application of UV Intermittent Sterilization for Indoor Mold Control and Cost- Effective Recovery of Heavily Mold/Moss-Contaminated Environments for Agricultural Usage

2.1 Layout and Irradiation Intensity Standards of 253.7 nm + 185 nm UVC Lamps in Indoor Environments

To ensure effective UV sterilization, the layout and installation of UVC lamps were designed in accordance with relevant national standards of the People's Republic of China. The sterilization target was defined for the UVC spectrum at 253.7 nm and 185 nm, where:

• 253.7 nm corresponds to the primary germicidal wavelength
• 185 nm contributes to ozone generation and indirect disinfection effects

This configuration ensures both direct DNA damage and indirect oxidative disinfection via ozone generation. Under these standards, the irradiance at the target surface must reach 70–90 μW/cm² within a distance of 1 meter from the UVC source (commercial products usually put the above two UVC spectrum in one product, here the 70–90 μW/cm² standard is for 253.7 nm). Relevant standards (People's Republic of China) include:

- GB/T 19258-2012 UV germicidal lamp
- GB/T 17262-2011 Single-capped fluorescent lamps – Performance specification
- GB/T 10682-2002 Double-Capped Fluorescent Lamps– Performance Specifications
- GB 28235-2011 Safety and sanitary standard for UV appliance of air disinfection
- GB 21551.3-2010 Antibacterial and cleaning function for household and similar electrical appliances - particular requirements of air cleaner
- GB 50073-2013 Code for design of clean room
- GB/T 17263-2013 Self-ballasted lamps for general lighting service – Performance requirements

Layout: The installation of UVC lamps was first determined based on relevant standards and the rated effective power of the selected devices. The actual irradiance intensity was then verified using a calibrated UV radiometer to ensure compliance with the required sterilization threshold.

2.2 Effects of UV Intermittent Sterilization for Indoor Mold Control under High-Humidity Conditions

Two North American wooden structures with highly comparable conditions were selected for a controlled experiment. These buildings, constructed in 1972 and equipped with air conditioning systems, represent a common type of storage facility widely used on farms in North America. Most of these structures have a history of mold contamination, making them particularly susceptible to recurrent fungal growth. The experiments were conducted at a constant temperature of 20°C. The room dimensions were:

- 2.93 × 5.09 × 2.65 m
- 2.82 × 5.19 × 2.77 m

Measurements were obtained using a portable laser distance meter on-site. Relative humidity (RH) levels of 60%, 70%, 80%, and 90% were established using air conditioning systems in combination with humidifiers. UV intermittent sterilization was applied according to the experimental design, with 30-minute UVC irradiation cycles. Within each room, three circular regions (diameter: 1 m) were designated on each of the wall, ceiling, and floor surfaces, resulting in a total of nine treated regions. Each day, 100 mL of tap water was applied to each designated region using a spray bottle to simulate high-moisture conditions. Adjacent to each treated region, three additional regions were maintained without water application and used as controls.

Mold growth was assessed by visual inspection, using the percentage of visible mold coverage relative to the total area of each region (mold area / total area × 100%). For approximately uniform circular growth patterns, coverage percentage was estimated based on radial expansion. In this study, visible mold coverage was used as the primary indicator of contamination, rather than conventional colony-forming unit (CFU) plate counting. This approach was adopted because UV intermittent sterilization is specifically designed for real-world environmental conditions, which differ

from standard laboratory culturing environments. Furthermore, visible mold contamination is strongly indicative of excessive fungal toxin levels, making it a practical and reliable indicator for evaluating contamination severity in this context.

One of the two rooms was subjected to 30-minute UV intermittent sterilization, while the other room served as a control without UV exposure. Observations were conducted over a 7-day period, and mean values with deviations were recorded. To avoid premature direct inactivation of fungal spores immediately after water application, UV irradiation was performed at least 4 hours after spraying.

day	60% RH sprayed	60% RH unsprayed	70% RH sprayed	70% RH unsprayed	80% RH sprayed	80% RH unsprayed	90% RH sprayed	90% RH unsprayed
1	0	0	0	0	17	12	24	26
2	72±11.6	32±9.2	75±10.4	55±9.3	100	58±8.3	100	62±13.8
3	92±7.2	45±8.3	90±4.3	63±6.2	100	85±8.9	100	100
4	92±4.3	48±5.6	100	91	100	100	100	100
5	96±3.1	50±7.3	100	96	100	100	100	100
6	98±3.3	66±6.5	100	100	100	100	100	100
7	100	71±11.8	100	100	100	100	100	100

Table 3: Comparison of Visible Mold Coverage on Sprayed and Unsprayed Wall Surfaces over 7 Days in an Indoor Environment without UV Intermittent Sterilization – the Impact of Moisture on Indoor Fungi Spreading

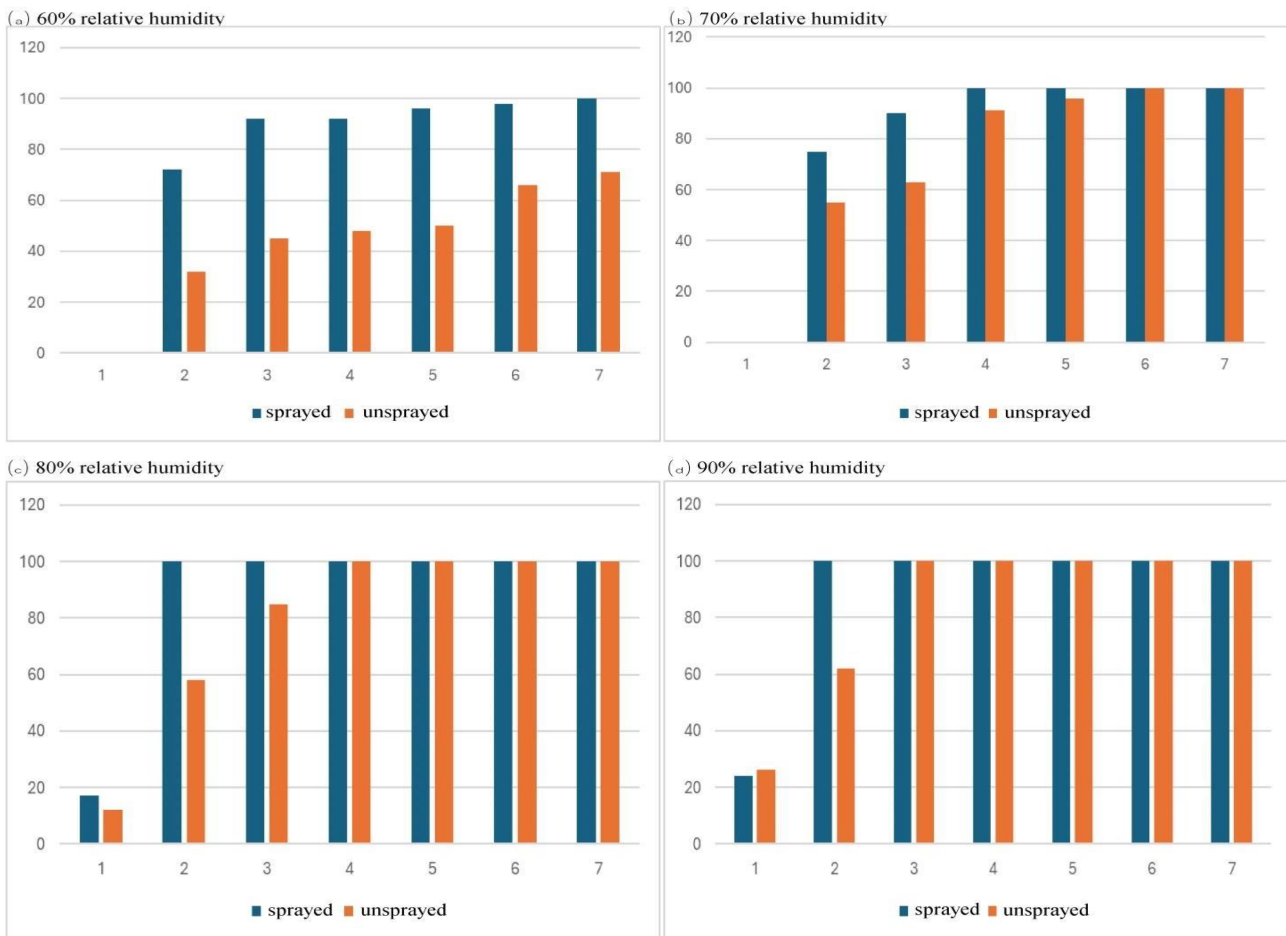

Figure 1: Visible Mold Coverage over 7 Days Under Varying Relative Humidity Conditions without UV

Under standard UV intermittent sterilization conditions with a 30-minute exposure, no visible mold growth was observed in indoor environments across relative humidity levels of 60%, 70%, 80%, and 90%, regardless of whether water spraying was applied. These results demonstrate that, under 30-minute UV intermittent sterilization, mold contamination cannot be initiated even under high-humidity conditions. This method is particularly suitable for controlling fungal contamination in indoor and semi-enclosed environments, such as livestock housing, grain storage facilities, and seed warehouses. It offers significant advantages in terms of low cost and operational simplicity. In contrast, achieving and maintaining temperature and humidity conditions required for safe grain or seed storage in enclosed or semi-enclosed environments is highly costly for a small family farmer. To a large extent, it is precisely this economic barrier that contributes to the widespread occurrence of aflatoxin contamination in food supply systems worldwide.

2.3 Validation of UV Intermittent Sterilization for Remediation of Severely Mold/Moss Contaminated Indoor Environments under High Humidity

The above-described rooms were used for remediation experiments under high-humidity conditions. Relative humidity was maintained at 90%, and continuous water spraying was applied to promote mold growth for 7 days. After this period, three severely contaminated regions (each 1 m²) were selected on the floor, walls, and ceiling for recovery testing. UV intermittent sterilization was then applied according to the standard protocol, with 30-minute irradiation cycles and a target UVC intensity of 70–90 μW/cm² at a distance of 1 m from the surface.

(a) The mold colony can be eliminated by 30min UV intermittent sterilization in 4 days

(b) Moss and lichen can be eliminated by 30min UV intermittent sterilization in 8 days

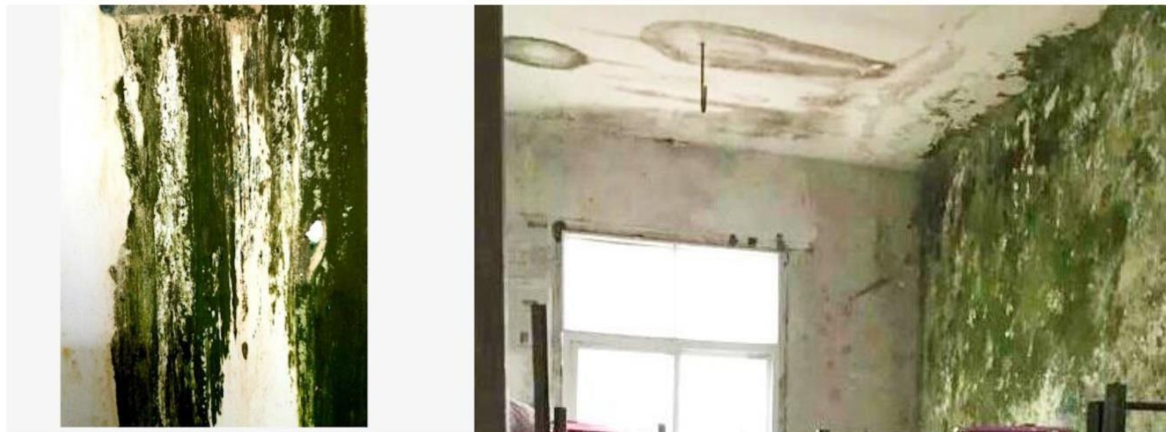

Figure 2: Effects of UV Intermittent Sterilization for Remediation of Severely Mold/Moss-Contaminated Indoor Space

Results showed that: mold on all six selected wall and ceiling regions was eliminated by day 3, with visible detachment of colonies, on the floor, two regions were cleared by day 3, and the remaining region by day 4, all visible mold- contaminated areas were completely removed within 4 days.

To further evaluate the method under more severe contamination, moss inoculation experiments were conducted. The same rooms were maintained at 90% RH, with daily water spraying and light exposure. Moss samples collected from natural environments were inoculated onto the walls at intervals of approximately 30 cm (each inoculation point ~1 cm in size). After one month, extensive moss growth developed. Three circular regions (diameter around 1 m) with moss thickness exceeding 1 cm were selected for treatment using the same UV intermittent sterilization protocol.

During irradiation:

- UVC intensity was maintained at least 70–90 μW/cm² at 1 m distance from the contaminated central surface.
- Water spraying and light exposure were continued to ensure sufficient moisture and growth conditions for moss.
- Moss and lichen, being more evolutionarily advanced than molds, often exhibit greater resistance to UVC irradiation. However, all three selected moss-contaminated regions were completely detached and eliminated within 8 days, with no subsequent regrowth observed. These results demonstrate that even for indoor environments with heavy moss or lichen contamination (thickness >1 cm), standard UV intermittent sterilization can achieve complete removal in 8 days, allowing the space to be restored for use without recurrence. It should be noted that, due to experimental standardization, the protocol employed 30-minute irradiation once every day. In practical applications, irradiation duration can be extended, such as 3 hours, twice a day without significant increase in operational cost.

These findings confirm the high efficiency, low cost, and broad applicability of UV intermittent sterilization for restoring severely contaminated environments. In contrast, chemical disinfection methods are often costly and ineffective under heavily contaminated conditions, such as those with extensive visible mold or moss growth. Moreover, without strict control of environmental humidity and temperature, fungal contamination tends to rapidly recur following chemical treatment. Chemical methods also raise concerns regarding chemical residues and the potential development of antimicrobial resistance. UV intermittent sterilization, by contrast, enables long-term control of mold and moss contamination under high-humidity conditions without the need for additional environmental controls. It can also restore heavily mold/ moss-polluted indoor spaces for use quickly and at a much lower cost. This approach offers a highly favorable cost-effectiveness profile, with no chemical residues and no risk of resistance development.

*** For heavily mold/moss polluted area environments similar to those shown, approximately one week of UV intermittent remedial sterilization is sufficient to restore the area for agricultural storage use. There is also no need for expensive structural renovation or additional control of temperature and humidity for continued implementation of this cost-effective method thereafter.

This approach provides a critical solution for combating stringent aflatoxin (AFT) contamination in global dairy and food systems.

3. Discussion of the Quantum Gravity Mechanism of the Patent and the Definition of EB

We have previously discussed EP (Environmental Participation) irrotational entropy and the Law of Entropy Degeneration [11]:

$$nk=nk+1+|\boldsymbol{EP}\rangle$$

Here, the term "irrotational" does not just concern the rotational condition in classical rigid body parameters, but rather represents a dynamic structural characteristic derived from condensed matter systems. Biological systems can essentially be viewed as room-temperature condensed matter structures, certain dynamics can be identified within the framework of condensed matter physics. For example, experimental studies on strongly interacting Fermi gases have yielded the following relationship [13]:

$$I/Irig=\delta^2$$

Where: I: Actual moment of inertia, Irig: Rigid body moment of inertia, δ: Cloud deformation parameter Experiments have shown that the moment of inertia of the system undergoes significant quenching. For instance:

$$I/Irig\approx 0.05$$

This indicates that the system does not undergo rigid rotation but instead forms a partially irrotational flow. According to Landau's two-fluid model, such irrotational flow can maintain a stable state with minimal energy dissipation, or without use system internal energy (entropy preservation state). In our theoretical framework, such irrotational structures require Environmental Participation (EP) to be sustained [11]. (Note: EP is defined as an internal motion originates from the non-rigid body characteristics, written down as $|\boldsymbol{EP}\rangle$ while quantized. There is no EP for a rigid body, however, here δ does not represent $|\boldsymbol{EP}\rangle$ itself; the extent of $|\boldsymbol{EP}\rangle$ components a rotational system can contain depends on the amount of superfluid fraction present. Spin cannot be directly calibrated by using I or Irig).

In 2019, we proposed that life originated from a whirlpool, with the dynamic force from superfluid spin. However, water vortices visible cannot be equated with macroscopic spin structures. So-called macroscopic spin exists only within the superfluid fraction of rotating water. For ordinary water vortices, the superfluid component may be so minute over a human lifetime or even centuries—that it remains undetectable with current experimental techniques. The irrotational entropy in living systems, by contrast, gradually accumulated and embedded in biomolecular structures over vast geological timescales, continuously strengthening through evolution. However, after billions of years of evolution leading to the biological structures observed today, the differences in irrotational entropy between living and non-living systems have become significantly measurable. Compared with a natural water vortex, which contains an almost negligible superfluid fraction, the proportion of superfluid components in the human body is estimated to have increased by a factor of approximately 10^9. In an adult, the measurable cerebrospinal fluid (CSF) volume is approximately 140–160 mL, with a daily turnover of about 500–700 mL—roughly 3–4 times the preserved CSF volume. The total CSF volume is estimated to exceed 1% of total body fluid. In contrast, in a natural whirlpool, the superfluid fraction is expected to be far below the parts-per-billion (ppb) level. Therefore, given a water body involves 100 tons of liquids; a concentration of 1 ppb corresponds to only about 0.1 mL, which is negligible compared to the daily CSF turnover of an adult with only 1/1000 body weight, it is therefore groundless to regard the visible whirlpool rotation as the quantum spin. Such substantial increase in superfluid proportion in bio-systems is attributed to the long term biological evolution in geological timescale. The somatic CSF spin dynamics span multiple scales, from intracellular microstructures to the

macroscopic spinal system, thereby governing the integrated dynamics of the entire organism. (Tap just a few milliliters of CSF via tap requires a person to remain recumbent for three hours to avoid somatic structural damage; in contrast, drawing 300 ml of blood from an adult has minimal impact on activity. These observations indicate that CSF aligns with entropy preservation, whereas blood largely close to the traditional energy conservation paradigm).

In prior research, through Cavendish mutation experiments, we measured empirical gravitational constant G:

Additionally, we conducted *FHD* (Falling Height Difference) tests [12] on a wide range of plant fruits and animals in living states, dead state, and also some liquid nitrogen freezing. These experiments consistently demonstrated a pronounced difference in irrotational entropy between living and deceased states.

These irrotational entropy differences almost entirely originate from the superfluid parts in a living organism. (When an animal is dropped freely from a height, it exhibits an observable *FHD* compared to a non-living metal block. However, after undergoing *CSF* tap and then being dropped from the same height, the FHD immediately decreases by at least 70%. Although it is technically challenging to completely drain all *CSF* from an animal in a single procedure, this partial tap experiment sufficiently dampens over 70% of the *FHD,* demonstrating that the gravitational effect originates largely from the superfluid component.)

In classical Newtonian mechanics and quantum mechanics, spin is typically considered a parameter independent of gravity. Only within the relativistic framework is there an extremely weak gravitational coupling. However, in biological systems, gravitational effects associated with spin are exponentially amplified by the surface tension structures and can be readily measured. This generality allows us to define an Entropy-stabilized Barycenter (EB) for bio-systems. It is the EB that accounts for the substantial differences in gravitational effects between living and non- living beings. In conventional quantum mechanics, microscopically symmetric spin is incorporated into the framework of angular momentum conservation through the representation theory of rotational symmetry: **J=L+S,** thereby formally subsumed into the energy conservation system. However, the EB we define here falls into entropy preservation instead of the conventional energy conservation paradigm. For non-living systems, whether in Newtonian or Einsteinian frameworks, the difference between mass and weight on Earth is typically negligible, allowing weight to serve as a reliable approximation of mass.

Recent advances in high-energy physics further support the view that mass and related physical observables are not purely intrinsic properties, but can emerge from underlying quantum structures. For example, studies of quantum chromodynamics (QCD) have shown that a large proportion of hadronic mass arises from confinement dynamics and vacuum fluctuations rather than from the bare masses of constituent quarks. In addition, experimentally observed spin correlations demonstrate that quantum properties originating from the vacuum can be preserved and propagated into measurable macroscopic states. These findings suggest that physical quantities such as mass and weight should be understood as structure-dependent and context-sensitive, rather than strictly equivalent in all systems [14]. For bio-systems, however, because the weight effect represents an entropy-stabilized barycenter, there is a significant difference between mass and weight attributable to this EB, rendering weight unsuitable for estimating mass. In defining the EB, we deliberately use “barycenter” rather than “centroid” to emphasize that the entropy-stabilized barycenter in living systems is a gravitational effect arising from dynamic mechanisms, distinct from the geometric center of mass in conventional rigid body systems.

The EB essentially constitutes an easily measurable |EP⟩, providing a means to assess and understand |EP⟩ that is otherwise challenging to measure directly (Bio-systems can be regarded as a spinal vector superfluid component together with peripheral structures under surface-tension regions, with EP (irrotational entropy) in both parts with different quantum levels. Here, the Entropy-Stabilized Barycenter (EB) reflects the integrated gravitational effect of the components rather than the isolated contribution of the superfluid alone: EB = EP + |EP⟩. Nevertheless, this integrated measure can still be empirically tuned to closely approximate |EP⟩. Most importantly, EB reflects bioactivity or aging; consequently, CRISPR/Cas9 can be understood as a mechanism by which the host aligns the EB of incoming DNA segments with the EB of its own genome, **a quantum gravity mechanism that has never been recognized by modern biology).**

Traditional quantum mechanics, when formulating the Schrödinger equation, theoretically neglects gravitational effects, considering them negligible relative to electromagnetic forces. Additionally, it posits that spin measurement induces wave function collapse to an eigenstate in the opposite direction—a “Bohr’s spooky collapse.” However, this collapse mechanism pertains only to symmetric spin systems. In biological systems, spin structures are often asymmetric (the fundamental cause of this asymmetry is the $|\boldsymbol{EP}\rangle$). Under these circumstances, the Law of Entropy Degeneration: $nk = nk{+}1 + |\boldsymbol{EP}\rangle$, actually describes a system where the superfluid undergoes continuous dynamic collapse, nk collapses to $nk{+}1$ and $nk{+}1$ collapses back to nk, etc. As long as $|\boldsymbol{EP}\rangle$ remains available, the system can sustain this essence of life process. Such bio quantum collapse can therefore be termed “linearity shifting collapse” (the non- simultaneous time required by living systems is accumulated from $|\boldsymbol{EP}\rangle$ during this linearity shifting). This process differs fundamentally in outcome from the Bohr spooky collapse. The traditional wave function collapses to a “dead eigenstate”, whereas nk, $nk{+}1$, and similar represent “alive eigenstates”, distinct from the conventional “dead eigenstates”. Precisely because gravitational effects can be ignored for the dead eigenstate Bohr spooky collapse, while the gravitational effects of superfluid structures undergoing “bio-active linearity shifting collapse” between nk and $nk{+}1$, and the $|\boldsymbol{EP}\rangle$ cannot be ignored,

we are therefore able to measure: $G_{bio\text{-}system} / G_{Cavendish} \approx 10^9$, which reflects the "weight" of "bio-active linearity shifting collapse structures" inside bio-systems (for non-living beings, even for condensed matter liquid strengthened by the extreme lower temperature conditions, the $G_{condensed}$ liquid is much more close to $G_{Cavendish}$ rather than approach to the $G_{bio\text{-}systems}$) condensed matter liquid strengthened by the extreme lower temperature conditions, the $G_{condensed}$ liquid is much more close to $G_{Cavendish}$ rather than approach to the $G_{bio\text{-}systems}$).

In Physics, the theoretical quantization of gravity for non-living matter is extremely challenging, with so many efforts but rare successful frameworks to date. Yet for life, which has evolved over billions of years, fully formed quantum gravity structures are ubiquitous; we even can't find any exceptions—no living organism lacking quantum gravity structures (at the genetic level, palindromes serve as the fingerprints of quantized gravity, representing a promising target for future investigations in quantum biology). From an applied perspective, the Kungfu practices of Shaolin (1,500 years of history) and Wudang (600 years of history) in ancient China constitute early applied practices of quantum gravity. Our model for simulating superfluids by Chu's constant [12] drew significant inspiration from these ancient physical practices. We can say that: **microscopically symmetric spin** corresponds to **a dead state measurement-induced Bohr spooky collapse,** whereas **macroscopically asymmetric spin corresponds to a living state structurally persistent linearity shifting aging**. In terms of experimental methodology, the Cavendish mutation approach requires sample destruction, where the *FHD* method allows in vivo testing. Both methods can be applied to assess the degree of aging in humans & animals, as well as the freshness of food and vegetables [12], providing a broad foundation for the practical application of the EB concept. Traditional freshness assessment methods often rely on sensory or chemical indicators, carrying a degree of subjectivity. The EB concept described in this paper, however, enables objective evaluation by measuring gravitational effects. The concept of "organic foods" is therefore become objectively measurable. Additionally, it is important to note that conventional weight measurement statically assesses mass to predict independent motion parameters of an object using Newtonian or Einsteinian formulas within an energy conservation framework. In contrast, the EB measurement presented here captures dynamic weight effects, representing kinetic intensity related to the *in vivo* environment under an entropy preservation paradigm. This constitutes a holistic kinetic parameter associated with aging, distinct from historically rigid parameters that can be independently derived. The previous Cavendish mutation experiments can therefore be written as:

$$\frac{G_{bio_system}}{G_{Cavendish}} = \frac{structurally\ persistent\ linearity\ shifting\ \text{aging}\ quantum\ state}{measurement\text{–}induced\ Bohr\ spooky\ collapse\ quantum\ state} = \frac{entropy\ presearvation}{energy\ conservation} \approx 10^9 \Rightarrow \frac{collapse\ to\ alive\ eigenstate}{collapse\ to\ dead\ eigenstate}$$

In the context of this patent's applications, EB is directly relevant to biological competition and sterilization efficiency Filamentous fungi such as Aspergillus spp. and Penicillium spp. do not exhibit high biomass when detected using DNA recovery from sterilized soil. However, when employing Petri dish methods in soil and natural environments, just these two genera account routinely for 70-90% of all plate colonies. This demonstrates their formidable competitive advantage relative to other microbial populations under equivalent environmental parameters—an advantage likely linked to their extracellular enzymes and mycotoxins. Both genera possess robust extracellular digestive enzyme systems, with saccharification occurring directly within the extracellular matrix . Consequently, the range of their entropy-stabilized barycenter (EB) extends far beyond that of most intracellular digestion microorganisms. Additionally, their production of mycotoxins —such as aflatoxins and penicillin—further enhances their competitiveness (this enhancement of competitiveness via mycotoxins should also be understood as a quantized process).

The intermittent UV sterilization described in this patent is fundamentally a quantized approach. If we were to pursue continuous UV irradiation to eliminate contaminating fungi, that would fall within the conventional energy conservation paradigm. However, the method employed here—using intermittent, multi-day exposures—represents entropy-preserving, quantized sterilization. This UV quantized sterilization method offers exceptional efficiency with strong cost-effectiveness in controlling feasibility. The distinction between quantized sterilization and conventional continuous sterilization lies in whether $|\boldsymbol{EP}\rangle$ participates in the process. $|\boldsymbol{EP}\rangle$ here plays a positive role in enhancing sterilization efficacy. Because filamentous fungi concentrate gravitational irrotational entropy at wound sites during healing, this weakens protective mechanisms elsewhere. When subjected to subsequent UV exposure, not only are the wounded areas attacked, but the relatively unwounded areas from previous irradiation also experience intensified attack. This effectively expands the compromised area. Multi-day intermittent irradiation exploits the $|\boldsymbol{EP}\rangle$ repair mechanisms evolved by organisms to implement a form of quantized, persistent sterilization—this constitutes the fundamental principle of the UV Intermittent Sterilization Patent. It is entirely distinct from conventional continuous UV sterilization, which merely damages DNA. The continuous process often induces highly adverse condition resistant dormant structures— such as endospores, spores and sclerotia, etc. to resist UV lethality. The quantized process, by contrast, induces target organisms to forgo such adverse resistant structures in favor of wound healing, rendering them even more vulnerable to subsequent UV exposure. It is the quantized factors that significantly enhances the efficacy of UV

sterilization and offer a feasible solution for global food AFT contamination threat.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have

appeared to influence the work reported in this paper.

Authors' contributions

JX, XL performed part of the experiments with the UV system. XC, CL, HZ experiments assistant and data analysis, YL developed the patent, performed all the entropic experiments, perceived the model and wrote the manuscript.

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紫外间歇灭菌技术用于控制曲霉属（*Aspergillus spp.*）传播并预防乳制品黄曲霉毒素（AFT）污染的：从量子引力线性飘移塌缩机制揭示生物体系熵稳定重心（EB）的定义

邢晶麗[1]，劉曉[1]，陳旭輝[1]，李超[1]，張寧[1]，賴昇宏[1,2]*

摘要

由曲霉属（*Aspergillus spp.*）等丝状真菌引起的黄曲霉毒素污染，长期以来一直是全球食品安全领域持续存在的重要挑战，尤其广泛存在于粮食储存、动物饲料储存及农业供应链体系中。基于我们早期的环境控制专利框架，以及 COVID-19 期间标准化建立的紫外（UV）灭菌实践，我们开发并系统化提出了一种**紫外间歇灭菌（UV Intermittent Sterilization）策略**，用于以低成本控制丝状真菌传播。该方法已被纳入面向农业应用的专利设计体系中。

与持续 UV 曝露不同，紫外间歇灭菌方法在设计上旨在提升操作效率，同时尽量减少材料老化并保证工程实施可执行性。其作用机制不仅仅局限于传统 DNA 损伤灭菌模型，量子化间歇 UV 照射可利用生物体系|EP⟩ **创伤修复补偿机制（wound healing compensation mechanism）**，使生物赖以生存的熵稳定重心（**Entropy-Stabilized Barycenter, EB**）失去生物功能。

EB 表示由生物体系表面张力区域所形成的一种可测量的引力性 **|EP⟩ 线性迁移相干结构（gravitational |EP⟩ linearity shifting coherences）**。这种对 EB 的量子化稳定性的干扰，可削弱丝状真菌的传播能力，从而抑制黄曲霉毒素污染。

关键词：曲霉毒素（Aflatoxin）；紫外间歇灭菌（UV Intermittent Sterilization）；熵稳定重心（Entropy-Stabilized Barycenter, EB）；微观对称自旋（Microscopic Symmetric Spin）；波尔幽灵塌缩（Bohr Spooky Collapse）；死亡本征态（Dead Eigenstate）；生物活性本征态（Bio-Active Eigenstate）；宏观非对称自旋（Macrocosmic Asymmetric Spin）；生命线性飘逸塌缩（Alive Linearity Shifting Collapse）

1. 紫外间歇灭菌专利简介

1.1 专利名称

使用紫外间歇方法及室内芽苗生产技术，在冬季乳制品奶牛及其它牲畜饲养系统中替代干草与青贮饲料，以根除黄曲霉毒素污染。

1.2 专利背景及其拟解决的食品安全问题

1.2.1 黄曲霉毒素作为公共健康与群体寿命的重要威胁

黄曲毒素（英语：Aflatoxin, 缩写 AFT），常由曲霉属（Aspergillus spp.）的几种真菌如： A. flavus, A. parasiticus, A. nomius 等引起食物饲料霉变产生 [1]. 广泛污染谷物、坚果、油籽等等及其制品。玉米、花生、大米等主粮作物中是 AFT 污染的主要载体[2]，此外，AFT 还存在于香料、咖啡、茶、乳制品等食品中，是目前为止最强的致癌物质，分解温度为 237－

306° C [1]，所以无法用任何食品或饲料加工方法去掉。自然界中至少存在 14 种黄曲毒素，主要有 B1、B2、G1 与 G2 等 4 种，当中又以 B1 的毒性最强 [2]。M1 及 M2 最早在饲喂霉烂谷粒的奶牛所产牛奶中发现，它们是其它黄曲毒素在动物肝脏中转变的产物，亦在寄生曲霉的发酵培养基中发现. 全球约有 120 个国家制定了各类食品和饲料中 AFT 安全标准 [2]，通常的液体牛奶为 0.5ppb （parts per billion）， 而饲料严格低于 20ppb。

目前世界各地 60-80%的粮食作物受到 AFT 污染[2]，有 45 亿人的健康受影响[1]。不过正因为 AFT 污染的控制难度比较大，目前广泛接受的食品标准还是大肠杆菌一类的细菌活菌标准，AFT 作为一种真菌毒素（mycotoxin）标准执行并不是很严格。因为执行活细菌标准大多数食品企业可以通过质控整改达标，但是如果严格执行真菌毒素 AFT 指标，大都数企业包括发达国家企业，食品招回比例都会远远超出其市场承受能力，很难通过质控整改解决。也就是说尽管 AFT 的危害远远高于目前的细菌指标，但是因为控制难度大招回比例高难以被市场承受，使得食品 AFT 标准的执行力度远低于活菌标准。常见食品 AFT 执行标准如下：

食品种类	总黄曲毒素限量（包括 Aflatoxin B1，B2，G1，G2）
花生、玉米	15 ppb 以下
米、高粱、豆类、麦类及坚果类	10 ppb 以下
食用油脂	10 ppb 以下
鲜乳	0.5 ppb 以下（以 M_1 计）
奶粉	5.0 ppb 以下（以 M_1 计）
其它食品	10 ppb 以下
任何类型饲料	严格低于 20ppb

Table 1: Representative Regulatory Limits for Aflatoxin Contamination in Major Food and Feed

需要特别注意的是，液体牛奶标准的严格低于 0.5ppb 不仅因为 AFT 是一级致癌物，也与儿童出生缺陷和发育迟缓显著相关[2]。

黄曲霉毒素对人体健康的主要危害包括：

- 慢性暴露导致肝细胞癌；
- 免疫功能抑制；
- 先天出生缺陷；
- 儿童生长发育迟缓等。

在发展中国家由乳制品引起的儿童健康问题比发达国家更为严重[2]。

有研究估计，长期摄入黄曲霉毒素超标乳制品的人群，其平均寿命可能缩短至少十年。这种寿命损失主要来源于两个方面：

第一，婴幼儿时期的暴露会严重影响机体生长与发育；

第二，癌症、肾功能衰竭、糖尿病及动脉粥样硬化等与衰老相关疾病，可能在人群层面提前 5–10 年出现。

现代医学实际上对这些疾病除了延缓以外没有任何有效手段，基本以五年存活期为标准。这

些疾病在人群水平的提前到来人均寿命冲击极大。在婴幼儿期对生长发育的冲击也显著埋祸这些疾病在老年期提前。有的人提倡素食，认为对长寿有好处，但是应该看到，只有先解决AFT 污染的素食才有意义，实际素食比肉食 AFT 污染机率高数十倍，盲目使用 AFT 污染的素食，在延寿目的上得不偿失。

1.2.2 饲料中黄曲霉毒素污染的真菌来源及大规模生产中的关键控制因素

霉菌(mold)，主要指曲霉(Aspergillus spp.)和青霉(Penicillium spp.)属的丝状真菌，因为用土壤平皿法分离土壤中真菌菌落一般 70%-80%都落在这两属。这种分离结果显示它们在相同孢子密度落到同一营养基质上载生长条件一致情况下能压制环境中其它真菌的竞争优势，这种环境竞争优势与其代谢能力强、快速生长、孢子形成能力强以及对多种环境条件的强大适应性密切相关[3]，也是食品 AFT 污染普遍存在的原因。在饲料，粮食和种子储存环境中，霉菌污染主体源于土壤[4]，控制发霉过程中湿度比温度更为关键[5]，在高湿条件下(>76% RH)，即使温度偏离霉菌最适范围，霉菌的生长和萌发仍然非常迅猛和难以控制[5, 6]。所以传统的干草类饲料霉菌控制主要依赖于湿度控制[8]，因为这点干草储存空间有防水屋顶，水泥地面或草垫能大大降低霉菌污染概率[8]，可惜大多数农户并不具备这种条件，阴雨地区污染率很高。青贮饲料是一种靠厌氧发酵压制霉菌生长繁殖的技术，必需繁育足够低氧或厌氧[9]良性微生物区系，一旦低氧或厌氧条件件控制不好，真菌毒素污染迅速上升[9]。另外青贮饲料储存空间必须湿度适中，既不能太干燥也不能太湿润，有时甚至比干草更难达标。由于这些技术门槛，干草及青贮的储存难度而生产中不达标的情况全世界普遍存在。

1.2.3 乳制品中黄曲霉毒素（AFT）污染主要来源于以下因素

① **干草**青贮饲料污染，冬季饲草不足情况下世界各地都是使用的干草、青贮饲料(多数玉米秸秆)和精饲料配合使用，这几类原料在储存使用过程中受潮发霉引起污染(冬季占总 AFT 污染的 70%以上)。

② 储存条件不足，除开干草和青贮，冬季饲料还加入精饲料，主要是谷物玉米等，这些配合干草青贮使用的精料储存条件达不到，同样受潮发霉。笔者在美国和加拿大探访过三十多个农场，基本都是木板饲料储存间，而大部分木板饲料储存间都有肉眼可见霉斑，这种仓库本身就是霉菌污染源，农场工作人员根本不在乎这种霉斑，因为FDA,USDA,CFIA,AAFC,OFMRA 等机构虽然已知湿度对仓储霉菌污染的疯狂助推效果，从而条例上严格要求“没有可见积水”，但是对于霉斑或者发生过霉斑的仓储空间管理非常松懈,只有非常少数审查员会叫清洁一下继续使用。由此造成无论审查人员还是农场工作人员对霉斑危害以及如何有效去除，缺乏足够认识。在中国情况更糟，小农场存料仓条件简陋，别说霉斑，连室内积水都管理都很松懈。我们应当认识到，有肉眼可见霉菌斑块的房间，霉菌孢子密度非常大，即使临时用化学消毒以后霉菌孢子密度几乎没有多少变化，遇到高湿下霉菌污染扩展非常迅速和难以控制，只要不严格使用本专利的紫外间歇灭菌方法进行室内储物空间低成本维护，仓储空间本身就是严重的霉菌污染源，由于多方面原因,上述官方机构对霉菌污染的监管，完全落于“无效监管”。这些事实也说明农场饲料储存间条件简陋而容易招致霉菌污染是世界各地非常普遍的情况。或许开始阶段有足够高水平的审查员是知道AFT 霉菌污染危害的，但是也清楚知道改造仓库空间湿度的成本难以承受，只好采用退而求其次的办法，例如只要求清理一下继续使用，这种松懈管理办法培训下的一批又一批审查员代代相传，造成整个审查群体对 AFT 污染危害越来越忽视，最后，绝大多数有国家执照的中国、美国、和加拿大农业仓储审查员都不清楚怎么有效控制饲料间霉菌孢子密度使其不至于危害并恢复该空间使用，足见本专利的社会食品安全需求性紧迫性和对社会文明的推动能力。

③ AFT 污染的隐蔽性：AFT 无色无味，热稳定性极高，牛奶生产者和消费者无法通过感官

判断其存在，导致长期摄入而不自知。长期摄入 AFT 超标乳制品人群估计会平均减寿 10 年。固态食物污染只危害成人，乳制品 AFT 污染则直接严重危害婴幼儿健康，严重冲击群体人均寿命。

1.3 专利实施与创新

紫外间歇灭菌技术创新的来源、操作方法、机制和使用场景

①该法来源

紫外间歇灭菌法源于美国专利 US2022/0314041 A1 及 US11554186 B1 的实践，最初用于控制空气中 COVID-19 的传播已取得良好效果。该方法通过隔日间歇性紫外照射，高效灭活空气中的传染性病原体。其产品已获得 Health Canada 的 interim COVID-19 二类医疗器械号 321987。不过该法在最初的临床试验中，仅设定了室内环境而未涉及湿度条件 [7]，因为 COVID-19 病毒传播跟湿度几乎无关。(通过感染病人呼出的 SARS-CoV-2 病毒，在自然环境中一般只能在 3 天左右维持感染力，在人群反复光顾的室内环境中，也仅能维持 2 周左右感染力，而且这些持续感染能力只与感染病人密度有关。但是空气和环境中霉菌孢子完全不同，它们对付各种恶劣环境的能力比霉菌营养细胞大很多倍，能轻易在各种恶劣环境中存活 3-5 年，一旦遇到合适湿度和营业物质马上迅速萌发繁衍，所以任何有一定营养的基质上，一旦遇湿在半天到一两天时间内就能长出肉眼可见的霉菌斑。）由于这些特点，**我们要把自我间歇灭菌推广至农业领域进行霉菌污染控制，就必须高度考虑高湿环境。由此实验得到的这套霉菌污染体系可低成本高效率用于控制室内或半开放空间，如粮食仓库，种子仓库，动物栏舍，食品生产区，还有人畜接触空气传染区(如 H1N1) 的霉菌污染控制应用。**

② 紫外间歇灭菌法的操作及机制

该方法通过隔日 30 分钟的紫外照射进行灭菌或表面消杀（时间可延长到 3hr,一日 2 次,另外,该法可以实现无人自动控制，进一步节省人力成本)。其机制是通过紫外 UVC 波段 253.7+185 nm 辐照，破坏微生物的 DNA 结构，使其失去繁殖和生存能力。第一次照射杀灭大部分营养细胞，但少部分微生物（如真菌孢子或细菌芽孢）可能未被完全杀灭，但 DNA 已严重受损，需要大量营养物质，湿度和 DNA 修复时间，而在修复期间，其生长和繁殖能力受到严重创伤。第二次及后续隔日辐照进一步追杀破坏微生物的 DNA 结构，由于微生物的数量和残存者受损虚弱，追杀效果显著增强。最终而被彻底杀灭。

③ 与传统湿热蒸汽间歇灭菌法的对比

廷德尔灭菌法（Tyndallization）是经典的间歇灭菌技术，由英国科学家 John Tyndall 于十九世纪提出。由于后来被 Robert Koch 广泛应用于微生物学研究训练，该方法在部分文献中亦被称为 Koch 蒸汽灭菌法。其原理是通过三次隔日加热**(100° C)和恢复室温循环，利用芽孢在间歇期萌发为营养细胞的特点，逐步追杀灭掉所有污染微生物。本发明的“紫外间歇灭菌法”与历史经典的科赫间歇灭菌法在原理上有相似之处：两者都通过隔日间歇性追杀操作：**科赫间歇灭菌利用芽孢萌发为营养细胞的弱点进行多次追杀，而紫外间歇灭菌法则通过微生物 DNA 修复损伤的弱点进行多次追杀。**这两种方法都体现了“诱导少数残留细胞发育并隔日追杀” 的核心原理。不过科赫间歇灭菌只用能用于小规模物品或者高附加值产品，因为要求 100° C 很难大规模使用，耗能也高。紫外间歇灭菌则能进行大规模消杀，特别对于空气中微生物灭菌是目前最有效方法，其高费效比和无污染无残留无耐药性特点非常利于大规模低成本推广应用。**

④ 紫外间歇灭菌法用于室内环境控制的技术创新验证试验

A. 环境中 253.7+185nm UVC 紫外灯布局和辐照强度标准(253.7nm 是杀菌波段，185 是臭氧波段) 为确保紫外杀菌效果，紫外灯的布局和安装按照各个产品相关中华人民共和国国家标准设定灭菌目标 UVC 253.7+185nm 波段 在距离消杀目标表面 1 米范围辐射强度必须达到 70-90 μW/cm²，有关标准：

- GB/T 19258-2012 Ultraviolet germicidal lamp

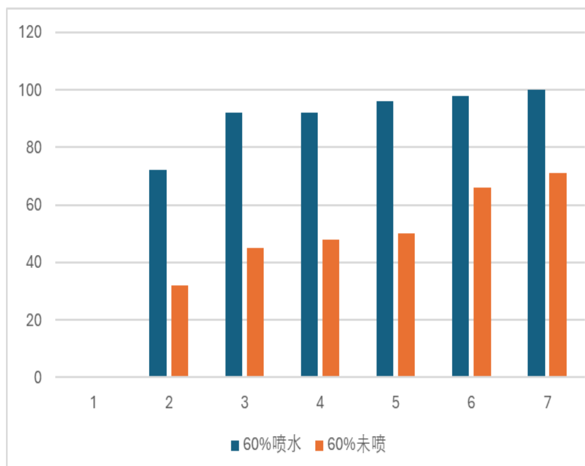
- GB/T 17262-2011 Single-capped fluorescent lamps – Performance specification
- GB/T 10682-2002 Double-Capped Fluorescent Lamps–Performance Specifications
- GB 28235-2011 Safety and sanitary standard for ultraviolet appliance of air disinfection
- GB 21551.3-2010 Antibacterial and cleaning function for household and similar electrical appliances-particular requirements of air cleaner
- GB 50073-2013 Code for design of clean room
- GB/T 17263-2013 Self-ballasted lamps for general lighting service – Performance requirements

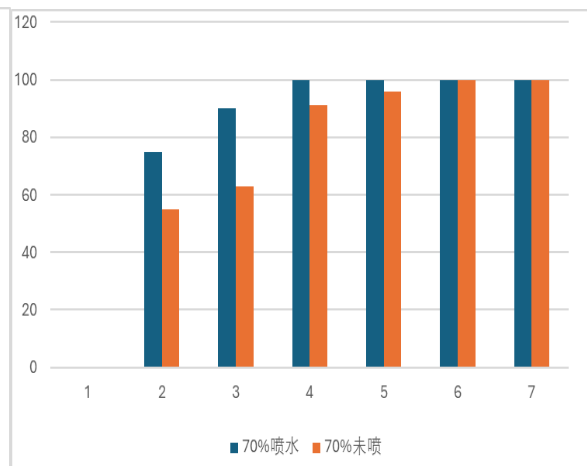
具体布局方法：先对照标准和产品选定基本有功功率，然后以紫外辐照仪验证实际辐射强度。

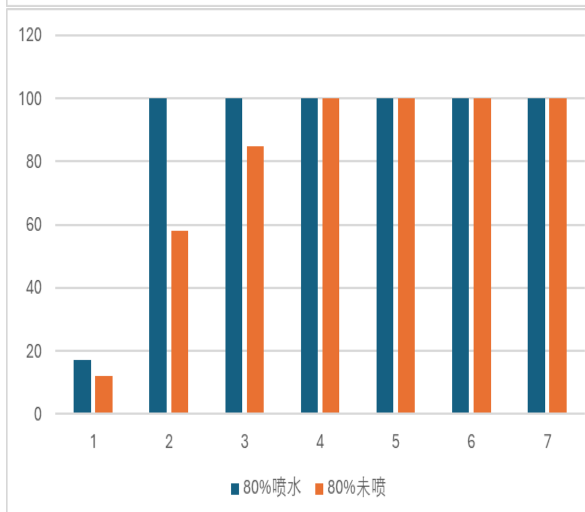
B 高湿度条件下的紫外间歇灭菌控制室内环境霉菌污染的效果

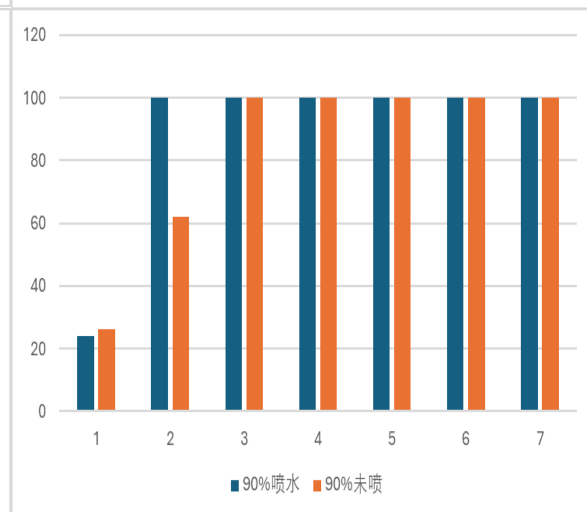
表 2. 未使用紫外间歇灭菌的室内空间喷水和未喷水的霉菌墙面污染面积在 7 天内对比（区域污染面积/区域总面积 × 100%）

时间（天）	60% 喷水区域	60% 未喷水区域	70% 喷水区域	70% 未喷水区域	80% 喷水区域	80% 未喷水区域	90% 喷水区域	90% 未喷水区域
1	0	0	0	0	17	12	24	26
2	72±11.6	32±9.2	75±10.4	55±9.3	100	58±8.3	100	62±13.8
3	92±7.2	45±8.3	90±4.3	63±6.2	100	85±8.9	100	100
4	92±4.3	48±5.6	100	91	100	100	100	100
5	96±3.1	50±7.3	100	96	100	100	100	100
6	98±3.3	66±6.5	100	100	100	100	100	100
7	100	71±11.8	100	100	100	100	100	100









选取两间条件尽量一致的北美老旧木板房(建于 1972 年，有空调，这种木板仓库大量存在北美农场，多数有过发霉史而易生霉菌污染)于 20° C 做对照试验，房间尺寸为：2.93×5.09×2.65m，2.82×5.19×2.77m(便携激光测距仪测定). 空调配合加湿器设定 60%、70%、80%、90% RH 并按紫外间歇灭菌条件安排 30 分钟紫外间歇灭菌紫外灯布局，然后在墙面，天花板，地面各划定 3 个直径 1m 圆形区域， 9 个区域每日用雾化瓶喷自来水 100ml，喷水区旁边 3 个区域作为未喷水对照，以肉眼可见霉斑面积/区域面积%×100 % 进行观察记录（对于生长均衡圆形区直接用半径估计近似百分比，本实验用肉眼可见区域面积作为污染评估，没有进行常规实验室平皿菌落计数，主要是因为我们的紫外间歇灭菌本身就是用于这种环境，而实验室通常的平皿计数通常适用的环境跟我们用的环境还是有一定区别。另外肉眼可见的霉菌污染区域真菌毒素肯定超标，足以作为方便可靠的快速检测技术进行试验，针对本专利实验完全能得出科学结论)。在两间房种一间使用 30 分钟紫外间歇灭菌而对照间不开紫外灯，7 天周期观察取三者平均值及偏差，注意：紫外灯照射时间必须离开喷水时间 4 小时以上避免刚喷上自来水区域真菌孢子过早被直接杀灭。结果见表 2.而使用紫外间歇灭菌常规 30 分钟时间的室内空间，对于 60%，70%，80%，90% RH 无论是否喷水，都没有出现肉眼可见霉斑,。这些结果证明在 30 分钟紫外间歇灭菌处理下，霉菌污染即使在高湿度环境也无法启动。这种方法特别适用于控制室内及半开放环境（如动物栏舍、粮仓、种子仓库等）的霉菌污染，且成本低廉，操作容易。相比之下，若想控制封闭或半开放室内环境的温湿度达成粮食或种子储存条件成本非常高昂。

C 高湿度条件下的紫外间歇灭菌对严重霉菌或青苔污染室内环境的杀菌恢复效果验证试验
选取上述房间，设定 90% RH 并雾化喷水，让霉菌污染区生长 7 天，然后在地面，墙面和天花板选取 3 个 1m² 霉菌污染严重的区域进行恢复试验，按上法设定紫外间隙灭菌标准设定 30 分钟辐照，按标准 30 分钟紫外间歇灭菌处理，墙面天花板 6 个区域霉菌在第 3 天脱落杀灭，地面两个区域第 3 天脱落，一个区域第 4 天脱落杀灭，所有肉眼可见真菌霉斑区被 4 天内清除。
选择上述房间设定 RH 90%，每天大量喷水光照，并且野外采集接种青苔(每隔 30cm 贴上 1cm 青苔)，一个月以后长处大面积青苔，墙面选取制作的青苔厚度超过 1cm 厚的 3 个 1m 直径区域按上述霉菌紫外间歇灭菌使用，同样设定青苔污染区中心点 1m 处紫外辐射强度 70-90 μW/cm²，紫外间歇辐照期间继续喷水光照，保证青苔有足够水源和光源。青苔和地衣进化程度高于霉菌，对抗紫外 UVC 辐照能力更高，但是 3 个选定的墙面青苔区域在第 8 天内全部脱落杀灭，后面无法恢复。试验结果征募，对于室内厚度大于 1cm 的青苔或地衣，也仅需 8 天的常规紫外间歇杀菌，青苔和地衣也能被去除，室内环境就可以恢复使用且不复发(因为操作标准化原因，本试验仅用 30 分钟隔日安排，实际使用中可以延长到 3 小时，而且一日 2 次，这样成本几乎不增加，但是消除霉菌污染空间并恢复使用的时间比实验种大大缩短)。这些发现证明紫外间歇灭菌法在恢复严重污染环境中的高效性和低成本广泛适用性。相比之下，化学方法或其他消毒方法不仅成本高，对付严重污染区，如上述肉眼可见大面积霉斑和青苔的室内环境，非常乏力，而且在消毒后若不加控制温湿度，真菌污染会迅速恢复。另外，化学法还有化学残留污染和耐药性问题。而紫外间歇灭菌无需额外控制温湿度，即可长期在高湿下低成本低杀灭室内环境中霉菌或青苔污染而恢复空间使用，费效比非常高，且没有残留污染和耐药性。

1.3.1.紫外间歇灭菌安全控制器（使得间歇灭菌进入 OTC 使用）

紫外间歇灭菌是一种非常高效低成本且没有化学残留和耐药性的霉菌污染控制方法，但于本专利并不是像普通各种消毒灭菌方法一样去使用，而是用紫外间歇霉菌在室内空间抑制霉菌产生肉眼可见的霉菌斑区，这种很特殊的室内霉菌污染控制用途，会带来一个安全弱项。就是当此空间有人员出入之时，254+185nm 紫外辐射不能直接照到人员裸露的皮肤和眼睛上。这就需要一个安全控制器，自动检测 3-5 米范围有人员时候停止紫外辐射，等人员离开一定时间再重新辐照（紫外间歇灭菌每天只要 30 分钟 UVC 辐照，时间提前推后对杀菌效果影响并不大)。原来在新冠 COVID-19 流行期间，我们在 Health Canada 得到了 interim order 的二类医疗器械号 321287，但是二类医疗器械限制只能医生护士在医疗机构空间进行处方使用，公众是不允许直接使用的，现在我们加入这个安全控制器，就能代替医生或护士进行安全控制，甚至比医生护士有更高控制效率，从而使得公众也能非处方使

用并进行室内空间霉菌污染控制。这个控制器原理为雷达或者红外感应，位于灯头附近，体积小而自动控制。这个安全控制器经过多次改进，目前可稳定高质量使用十万次，代替医生护士功能并极大保护使用者安全，成功进入公众非处方安全使用。

1.3.2. 室内芽苗生产技术创新

芽苗是直接用种子在室内可控环境中，通过调节温度、湿度和光照，快速生产高营养价值的芽苗。芽苗都不接触土壤，通常情况芽是指没有光照的绿色而苗是指有光照绿色的产品。其生产周期短，4-14天范围，即发即用，无需长期储存，可实现室内工厂化生产。营养价值高，富含蛋白质、维生素和矿物质。由于我们的紫外间歇灭菌用于种子保存和芽苗生产各环节，加上芽苗本身不接触土壤，霉菌污染机会很低。另外，霉菌污染的种子无法发芽，发芽过程本身就能剔除污染种子，即使生产过程中临时造成少量污染（一般即使种子污染严重的外来种子，成品污染率也只有 5-10%），也很容易在生产环节中挑选出来，芽苗霉菌污染机会几乎为 0。另外由于生产周期短，不要储存时间，也大大降低污染。这种利用芽苗生产过程把霉菌污染剔除的过程通称芽苗对霉菌污染的“自净作用”。虽然室内芽苗工厂化生产工艺和设备已发展多年，质控工艺非常成熟，能通过环境条件控制、无土壤接触和快速生产等提供高质量、无霉菌污染的芽苗，有些生产过程甚至已经做到自动控制。但是把室内芽苗生产中“芽苗自净作用”用于防止奶牛冬季饲料 AFT 污染则是本专利创新，无人做过，属于本专利“室内芽苗生产自净作用” 创新。

1.3.3 GrowFresh 食品保鲜技术创新

传统的新鲜蔬菜保鲜方法主要依赖收获后的低温储藏和包装技术。常见方法包括：

- **使用包装或改良气调包装（MAP）；**
- **将蔬菜存放在 4°C 的低温环境；**
- **采用氮气冲洗或调节氧气、二氧化碳比例以抑制微生物生长和植物呼吸。**
- **此外，一些产品还会进行预冷、清洗消毒和冷链运输，以延长货架期。然而，这类方法通常有以下特点：**

蔬菜在采收、清洗和包装后，已脱离其原本的生长系统；
植物组织逐渐进入衰老状态；
即使采取多种技术干预，蔬菜的保鲜期通常难以超过两周(14 天)；
需要持续冷链运输，并且包装成本较高。
GrowFresh 保鲜系统的创新点：

- **该系统通过维持植物处于持续生长状态来保鲜：**
- **蔬菜在收获后不是以“储存状态”提供给用户，而是以活生长的植物形式供给；**
- **这种方式显著延长了保鲜周期；**
- **减少了对低温存储和复杂包装系统的依赖，从而降低了能源和材料成本。**

“GrowFresh”商标本身即代表植物在生长状态下保持鲜活。
在以往实验中，我们比较了不同条件下绿豆和黄豆种子的物理熵稳定性（FHD，Failing Height Difference）：发芽 24 小时和 48 小时的豆芽，其 FHD 测量值明显高于相应原种子；这表明，在萌发阶段，植物系统的结构稳定性显著增强；换句话说，处于生长阶段的植物系统具有更高的熵稳定重心（Entropy-Stabilized Barycenter，EB）。
在实际的 GrowFresh 应用中，蔬菜的新鲜度不再依赖主观视觉评估，而是可通过无旋熵稳定性（irrotational entropy stability）进行客观测定。因此，我们将这一保鲜方法称为：
“重力无旋熵鲜度保持或检测技术”（gravity irrotational entropy freshness preservation or detection technology）
此外，喂食经过 GrowFresh 保鲜饲料的奶牛，其产出的牛奶显示出显著的双歧杆菌促进特性（bifidogenic properties），并以 Bifidogen 商标销售。这表明：
饲料中存在的 EB 能够传递至乳制品中；相较于传统乳制品，牛奶具有更高的熵稳定性。

1.3.4. 室内芽苗生产盒装（boxing）技术创新

盒装技术是指芽苗播种和收获同一容器，这也是大规模生产中有利于防止霉菌 AFT 污染提高质量的技术创新之一，可防止污染芽苗继续污染良品，并且利于挑选次品，是实现大规模生产中自动控制基础和降低人力物力关键。在现有各种芽苗工厂化生产技术和设备中并无此技术，也属本专利创新。

1.3.5. 冬季奶牛饲料储存空间创新

在奶牛冬季饲料供应中，传统干草和青贮饲料需要很多储存空间，现在改用我们专利，冬季只需要储存种子，就大大解决奶牛冬季饲料长期面临储存空间大、霉菌污染风险高、生产成本高等问题。**芽苗技术则只需要储存种子，一斤种子可以生产十斤芽苗，还可动态生产：边生产边喂养，无需一次性储存整个冬季的饲料，进一步降低空间压力。相反，传统干草和**青贮饲料必须准备足够整个冬季用量，生产周期数月，很难做到动态生产。**这些因素通称为**，称为“奶牛冬季饲料储存空间创新”，具有良好经济价值和食品安全优势，总结如下表：

芽苗技术与传统干草和青贮在冬季奶牛饲料存储空间上对比优势

	芽苗技术	**干草**	**青贮饲料**
储存空间	空间需求小，动态生产	空间需求大，一次性储存	空间需求大，一次性储存
生产成本和外部专业化供货	种子可奶牛场外专业化分工生产，规模成本低，经济和人力成本低，	人工和设施成本高，难以专业化分工生产，难自动化	设施和管理成本高，难以专业化分工生产，难自动化
霉菌污染控制程度	自净+紫外间歇，高湿度也无污染	靠天气湿度控制，污染风险高	依密封发酵和中湿度，污染风险高
AFT 污染	完全无霉菌污染	污染普遍存在	污染普遍存在
添加剂污染	无需添加剂，无污染	无添加剂	化学添加剂有二次污染和耐药性问题，微生物添加剂成本高效果低
生产周期	1-2 周，短周期，种子能动态储存	数月，长周期，无法动态储存	数月，长周期，无法动态储存
技术门槛	低，易于自动化	中，需控制湿度	高，需严格密封和发酵管理
适合规模	适合大规模和小规模生产	大规模生产中问题多	大规模生产中问题多
腾出土地问题	减少占用牛场地，腾地养更多奶牛	需要牛场土地生产，无法腾地	需要牛场土地生产，无法腾地
供货商距离	供货种子可低成本长途运输	外购干草因运输成本只能就近	外购**青贮因**运输成本只能就近

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