## **Processing & Post-Harvest Mechanics Design v1.1**

**I. Introduction**

This document details the design and mechanics for Project Chimera's multi-stage processing and post-harvest systems. These systems are crucial for transforming harvested cannabis into high-quality, marketable products, thereby realizing the genetic potential meticulously cultivated by the player. The core philosophies underpinning these mechanics are realism in process, meaningful player agency through optimization choices, a clear progression from manual to automated methods, and the significant impact of these processes on final product attributes like potency, aroma, flavor, appearance, and shelf-life. Success in post-harvest handling is as vital as successful cultivation for achieving top-tier results and maximizing returns.

**II. Multi-Stage Post-Harvest Processes**

The journey from a harvested plant to a finished product involves several critical stages, each with its own set of parameters, equipment, and impact on quality.

**A. Drying**

The initial and one of the most crucial steps to preserve the harvest and prevent degradation.

* **Methods & Equipment:**
  + **Hang Drying:** Players can hang whole plants or large branches upside down in a controlled environment. This often involves using lines or wire hangers within the drying space.
  + **Rack/Tray Drying:** Cut branches or individual buds can be laid out on perforated drying trays or mesh racks. This method might be preferable for larger quantities or specific trimming workflows.
* **Environmental Targets & Control:**
  + The "Dry Room" environment must be carefully managed for optimal temperature, humidity, and airflow. Players will utilize equipment like fans, dehumidifiers, AC units, and potentially heaters (from their HVAC systems ) to achieve these targets.
  + **Temperature:** Generally cooler temperatures (e.g., 60-70°F or 15-21°C) are preferred to slow down the degradation of volatile compounds like terpenes and cannabinoids.
  + **Humidity:** Moderate relative humidity (e.g., 45-55% RH) is typically targeted. Too high risks mold; too low causes overly rapid drying.
  + **Airflow:** Gentle, indirect airflow is essential to remove moisture and prevent mold, but strong, direct airflow can cause rapid, uneven drying.
* **Impact on Quality & Drying Time:**
  + **Optimal Drying (Slow & Controlled):** Achieved through maintaining the target environmental parameters. This method best preserves terpenes (aroma/flavor) and cannabinoids, resulting in a smoother, higher-quality product, but takes longer (e.g., 7-14 in-game days, influenced by bud density and room conditions).
  + **Suboptimal Drying (Too Fast/Slow/Humid/Hot):**
    - *Too Fast (Low RH, High Temp/Airflow):* Leads to harshness, loss of delicate terpenes, and buds that are dry on the outside but still wet inside.
    - *Too Slow (High RH, Low Airflow):* Creates a high risk of mold and mildew, potentially ruining the harvest. Can also lead to hay-like smells due\_to\_chlorophyll not breaking down properly.
* **Progression:**
  + **Early Game:** Players might use a basic, manually controlled room or even a grow tent converted for drying, relying on simple fans and dehumidifiers.
  + **Mid-Late Game:** Players can construct dedicated, insulated "Dry Rooms" with advanced, automated HVAC systems, environmental controllers, and data logging to maintain precise conditions. This links to progression in the "Environment" and "Construction" skill trees. The "Controlled Drying Processes" node in the "Harvest" skill tree unlocks understanding and better equipment for this.

**B. Curing**

Following drying, curing is essential to develop the final bouquet, flavor, and smoking characteristics of cannabis flower.

* **Mechanics:** Involves transferring appropriately dried buds into controlled-atmosphere containers to allow for a slow, further equalization of moisture and the breakdown of chlorophyll and other undesirable compounds, while preserving and enhancing desirable ones.
* **Containers & Equipment:**
  + **Early Game/Small Scale:** Glass Mason Jars are a common starting point.
  + **Mid Scale:** Larger food-grade plastic buckets with airtight lids (e.g., Gamma Seal Lids ) can be used.
  + **Late Game/Industrial Scale:** Specialized stainless steel curing vessels, large totes, or even entire climate-controlled curing rooms become options.
  + **Humidity Control Packs:** (e.g., Boveda-style packs ) can be used in containers to help maintain specific RH levels.
  + **Small Digital Hygrometers:** Placed inside containers to monitor RH.
* **Environmental Stability & Parameters:**
  + Curing containers should be stored in a cool, dark, and stable environment to prevent degradation from light and temperature fluctuations.
  + The target RH inside the curing container is typically 58-62%.
* **Curing Profiles & "Burping":**
  + **Standard Cure:** Involves regularly opening containers ("burping") for a short period (e.g., daily for the first week, then less frequently) to release excess moisture and exchange air. Duration can range from 2 weeks to several months.
  + **Extended Cures:** Some players may opt for longer curing periods, believing it further enhances smoothness and complexity, though this requires exceptionally stable conditions and carries a risk of over-drying if not managed.
  + **Strain-Specific Curing:** The game could subtly model certain strains benefiting from slightly different curing RH targets or durations, discoverable through experimentation.
* **Monitoring & Automation:**
  + **Manual:** Relies on players placing hygrometers in jars, manually opening them for burping, and assessing readiness by feel and smell.
  + **Automated (Late-Game):**
    - "Smart" curing containers with integrated RH sensors and automated micro-venting systems.
    - Climate-controlled curing rooms that precisely manage the ambient RH around semi-permeable curing containers.
  + Progression in the "Harvest" skill tree, particularly "Curing Sci. & App.", unlocks knowledge, techniques, and potentially better equipment/automation options for curing.

**C. Trimming**

The process of removing excess leaves from dried cannabis flowers to improve appearance, smokability, and potency concentration.

* **Options & Trade-offs:**
  + **Manual Hand-Trimming:**
    - *Equipment:* Trim scissors (micro-tip, curved/straight types).
    - *Process:* Player meticulously cuts away sugar leaves and fan leaves from the buds. Can be done "wet" (before drying) or "dry" (after drying – generally preferred for quality).
    - *Pros:* Highest quality product, best appearance ("bag appeal"), maximum preservation of trichomes. Allows for careful separation of high-quality trim for other uses.
    - *Cons:* Extremely slow and labor-intensive.
    - *Unlocks:* Core technique learned via "Trimming & Preparation" skill node.
  + **Semi-Automated Trimming:**
    - *Equipment:* Manual or electric "bowl trimmers".
    - *Process:* Buds are placed in a device that tumbles them over grates with cutting blades.
    - *Pros:* Significantly faster than hand-trimming, reduces labor.
    - *Cons:* Can be rougher on buds, leading to some trichome loss and a less manicured appearance compared to hand-trimming. Quality of trim is often lower.
  + **Fully Automated Trimming:**
    - *Equipment:* Industrial-scale automated trimming machines.
    - *Process:* Larger machines that use tumblers, blades, and sometimes vacuum systems to process large quantities of cannabis quickly.
    - *Pros:* Highest speed, lowest labor cost per unit for very large volumes.
    - *Cons:* Highest initial equipment cost. Generally the most aggressive on buds, can lead to significant trichome loss and a more processed appearance. Often used for biomass intended for extraction or lower-grade flower products.
    - *Unlocks:* Tied to late-game "Post-Harvest Efficiency (Bulk Processing & Basic Auto.)" skill node.
* **Kief Collection:**
  + During dry trimming, especially when using trim bins with kief screens, players can collect fallen trichomes (kief), which is a valuable, potent byproduct. Automated trimmers may also have kief collection systems.

**D. Advanced Extraction Techniques** (Post-MVP or Significant Late-Game Content)

Creating cannabis concentrates like oils, shatter, wax, and isolates. This represents a major expansion of post-harvest activities. The Asset List notes this as "Potential Future/High Tier".

* **Specialized Equipment Required:**
  1. **Solventless Extraction:** Rosin presses (utilizing heat and pressure).
  2. **Solvent-Based Extraction (Abstracted System):**
     + *Extraction Vessels:* For washing cannabis material with a solvent (e.g., ethanol, CO2 – the specific solvent mechanics can be abstracted for gameplay).
     + *Winterization Equipment:* Lab freezers, filtration apparatus (Buchner funnels, filter paper) to remove fats, waxes, and lipids.
     + *Distillation Apparatus:* Short path distillation kits or wiped-film evaporators for refining and isolating cannabinoids to create high-potency distillates.
     + *Purging Equipment:* Vacuum ovens for removing residual solvents from extracts.
* **Multi-Step Processes & Optimizable Parameters:**
  1. **Material Preparation:** May involve specific grinding consistency, decarboxylation (heating to convert acidic cannabinoids like THCA to their neutral forms like THC), or flash-freezing.
  2. **Extraction Run:** Parameters such as solvent type (if choices are offered), temperature, pressure, and soak/flow time will affect yield and the profile of extracted compounds.
  3. **Winterization/Dewaxing (for some extracts):** Holding the crude extract at very low temperatures in a solvent to precipitate fats and waxes, followed by filtration.
  4. **Solvent Recovery/Purging:** Evaporating and (ideally) recovering the solvent, often under vacuum, to ensure the final product is safe and clean.
  5. **Distillation (for high purity):** Separating cannabinoids based on boiling points to create highly potent distillates.
  6. **Post-Processing:** Whipping, agitating, or specific temperature manipulations to achieve desired concentrate consistencies (e.g., badder, crumble, sauce).
* **Quality Factors:** Each parameter in each step can influence the final concentrate's yield, purity, potency, flavor (terpene retention), and consistency.
* **Progression:** Would require a dedicated "Extraction Science" or "Advanced Processing" branch in the "Science" skill tree, or a new specialized skill tree. This involves significant in-game investment in specialized lab equipment, dedicated facility space (potentially with safety features like ventilation for solvent use), and advanced knowledge.

**E. Edible & Topical Production** (Further Post-MVP or Significant Late-Game Content)

Transforming cannabis flower or extracts into consumable or applicable products.

* **Specialized Equipment Required:**
  + Commercial-grade kitchen equipment: Mixers, ovens, stovetops, double boilers.
  + Infusion equipment: For infusing fats (butter, oils) with cannabinoids.
  + Homogenizers: To ensure even distribution of cannabinoids in mixtures.
  + Molds: For gummies, chocolates, etc.
  + Filling & Depositing Machines: For accurately dosing and filling edible products or topical containers.
  + Quality control tools: (Simulated) lab testing equipment for batch potency.
* **Recipes & Formulation:**
  + Players would need to acquire or research recipes for various products.
  + Recipes would specify ingredients, cannabis input type (flower, extract, distillate), infusion methods, cooking/mixing parameters, and target dosage per unit.
* **Quality Control & Dosage Consistency:**
  + A critical gameplay mechanic. Producing edibles/topicals with consistent and accurate dosage would be a challenge, requiring precise measurements and potentially batch testing (simulated). Inaccurate dosing could lead to reputation penalties or product recalls (in-game).
* **Packaging Lines:** Specific equipment for packaging individual edible units (e.g., wrappers, child-proof containers) or topicals (jars, tubes).
* **Progression:** Would likely involve a dedicated "Product Formulation," "Culinary Science," or "Pharmaceutical Compounding" skill tree branch, plus investment in food-grade processing facilities and advanced QA/QC equipment.

**III. Designing Packaging Processes**

Preparing the final product for simulated sale, distribution, or long-term storage.

* **Core Steps:**
  + **Weighing:** Accurately weighing the product (flower, concentrates, edibles) using various tiers of digital scales (from pocket scales for small amounts to bench scales for larger quantities).
  + **Containerization:** Placing the weighed product into appropriate primary packaging:
    - *Flower:* Mylar bags, glass jars, pre-roll tubes.
    - *Concentrates:* Small glass or silicone containers, vape cartridges.
    - *Edibles/Topicals:* Specific wrappers, pouches, jars, tubes designed for those products.
  + **Sealing:** Ensuring freshness and preventing contamination:
    - Heat sealers for Mylar bags.
    - Vacuum sealers for long-term storage of flower or creating certain types of packaging.
    - Lid applicators for jars/containers.
  + **Labeling:** Applying labels that include:
    - Strain name / Product name.
    - Company branding (player's "company").
    - Batch number / Harvest date.
    - Potency information (THC, CBD percentages – derived from in-game lab testing).
    - Net weight.
    - Potentially other compliance information (simulated).
    - This could start as manual label application (using label/marker assets ) and progress to automated label printers and applicators.
  + **Secondary Packaging (Optional):** Boxing or casing multiple individual units for bulk sale or distribution.
* **Automation Levels:**
  + **Manual:** Player performs all steps using basic tools.
  + **Semi-Automated:** Introduction of equipment like automated weigh-and-fill machines for flower, conveyor belts to move products between stations, tabletop label applicators.
  + **Fully Automated (Late-Game):** Integrated packaging lines that handle multiple steps from weighing to sealing and labeling, requiring significant investment and facility space.
* **Progression & Unlocks:** Packaging equipment and automation capabilities could be unlocked via the "Business" skill tree (related to market presentation, efficiency, and scaling sales) or a dedicated "Processing & Logistics" branch in the "Harvest" or a new skill tree.

**IV. Managing Post-Harvest Perishability & Quality Degradation**

Cannabis is an agricultural product, and its quality degrades over time if not handled and stored correctly. This section emphasizes the time-sensitive nature of post-harvest operations.

* **Core Principle:** Time, temperature, light, oxygen, and humidity are the primary enemies of harvested cannabis quality. Minimizing negative exposure to these elements is key.
* **Time-Sensitive Urgency & Workflows:**
  + **Immediate Post-Harvest:** Freshly harvested plants are vulnerable to mold and rapid degradation. They must be moved to the designated drying environment promptly. Delays here can severely impact the final product.
  + **During Drying:** Maintaining stable and optimal environmental conditions is paramount. Fluctuations or rushing the drying process will lead to significant quality loss (terpenes, cannabinoids, smoothness).
  + **During Curing:** Consistency in the curing environment and adherence to proper burping schedules are essential. Mistakes here (e.g., forgetting to burp, curing in unstable temperatures) can easily ruin an otherwise excellent harvest, leading to mold or hay-like smells.
  + **Long-Term Storage:** Properly dried and cured cannabis must be stored in airtight containers (e.g., Mylar bags, vacuum-sealed bags, glass jars with good seals ) in a cool, dark, and stable environment. Oxygen absorbers could be an option for very long-term storage. Exposure to light, heat, fluctuating humidity, and oxygen will degrade cannabinoids and terpenes over time.
* **Strategies to Minimize Degradation:**
  + **Efficient Facility Layout:** Designing the facility with a logical flow from harvest areas to drying rooms, then to trimming/curing areas, and finally to secure storage, minimizing travel time and exposure of the product to uncontrolled environments.
  + **Batch Management & Tracking:** Implementing a clear in-game system for players to label and track individual harvest batches through each post-harvest stage. This helps prevent batches from being forgotten, mishandled, or processed out of sequence.
  + **Dedicated Environmental Controls:** Utilizing advanced HVAC and environmental control systems (unlocked through progression) in drying, curing, and long-term storage rooms to maintain precise and stable conditions.
  + **Inventory Management (FIFO):** If the game involves selling products over time, a First-In, First-Out (FIFO) inventory principle should be encouraged or subtly enforced (e.g., older stock might show slight degradation if held too long, incentivizing its sale first).
* **Feedback Mechanisms for Quality Degradation:**
  + **Visual Cues:** Obvious signs like mold growth on improperly dried or cured product. Changes in color (e.g., browning of flower over time if stored badly). Reduced trichome vibrancy.
  + **Data/Testing:** (Simulated) lab tests on stored products could show a gradual decrease in cannabinoid potency or a shift in the terpene profile over extended periods or if storage conditions are poor.
  + **Market Value / NPC Feedback:** Degraded products should fetch significantly lower prices from NPC buyers or in any future player-driven marketplace. NPCs might provide specific feedback like "This batch smells stale" or "Potency seems lower than expected for this strain."

**V. Conclusion**

The Processing & Post-Harvest Mechanics in Project Chimera are designed to be a deep and integral part of the gameplay experience. By providing players with a range of techniques from manual and artisanal to industrial and automated, the game will allow for diverse playstyles and strategic choices. The detailed management of drying, curing, trimming, and potentially extraction and edibles production, combined with the realities of perishability, will challenge players to master not just cultivation, but the entire lifecycle of their product. Success in these final stages will be crucial for maximizing the quality and value derived from their meticulously grown and bred cannabis, closing the loop from seed to saleable product in a rewarding and realistic manner.