Pre-analysis Report for Chamomile Freshness Experiment

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1 Experiment setup

The experiment is designed to study how temperature and water availability affect the short-term survival, freshness, and appearance of chamomile flowers. We basically want to address the following three questions.

Question 1. *Temperature effect: Do chamomile stems last longer when stored in a cold place (like a fridge) compared to room temperature?*

Question 2. *Water effect: Do chamomile stems last longer when placed in water compared to being kept dry?*

Question 3. *Interaction effect: Does the benefit of cold storage depend on whether the chamomile stems are in water or not?*

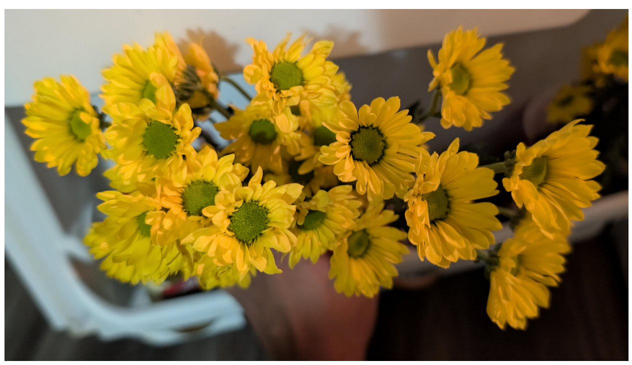

Figure 1: Close-up view of freshly cut chamomile flowers before the start of the experiment.

Figure 2: All chamomile stems laid out and labeled prior to random assignment to experimental groups. Each stem was numbered.

Each group contains one or more cups of chamomile stems. The cups are assigned randomly to the four conditions to avoid bias. Every cup is labeled and photographed before starting. We (will) observe each chamomile cup once or twice a day and record: **(1)** time to wilt: number of hours (or days) until the first clear wilting of the chamomile blooms or drooping of stems. **(2)** number of chamomile flowers still fresh per stem, and **(3)** water loss: for cups with water, measure how much water is absorbed or evaporated each day.

If a stem remains healthy until the end of the study, its time-to-wilt is recorded as "not yet wilted" (thus, right-censored). All observations are photo-documented under consistent lighting and angle.

2 Statistical Analysis

2.1 Notation and Targets

Let $T_j \in \{0, 1\}$ denote the `temperature indicator` for cup j ($19.44°C$ for room temperature and $2.22°C$ for fridge temperature) ($1 =$ `cold`, $0 =$ `room`), and $W_j \in \{0, 1\}$ denote the `water indicator` ($1 =$ `in water`, $0 =$ `dry`). For stem i in cup j, let Y_{ij} be the `time-to-wilt`.

We aim to estimate average differences in the `mean survival time` (how long chamomile stays fresh) and `freshness scores` between treatment groups.

Formally, define

$$\mathtt{Mean}_{T,W} = \mathbb{E}[Y_{ij} \mid T_j = T,\, W_j = W],$$

then the factorial effects are given by

$$\begin{aligned}
\texttt{Effect of Temperature:} \quad & \Delta_T = \tfrac{1}{2}\big[(\mathtt{Mean}_{1,0} + \mathtt{Mean}_{1,1}) - (\mathtt{Mean}_{0,0} + \mathtt{Mean}_{0,1})\big], \\
\texttt{Effect of Water:} \quad & \Delta_W = \tfrac{1}{2}\big[(\mathtt{Mean}_{0,1} + \mathtt{Mean}_{1,1}) - (\mathtt{Mean}_{0,0} + \mathtt{Mean}_{1,0})\big], \\
\texttt{Interaction:} \quad & \Delta_{TW} = \mathtt{Mean}_{1,1} - \mathtt{Mean}_{1,0} - \mathtt{Mean}_{0,1} + \mathtt{Mean}_{0,0}.
\end{aligned}$$

Each effect measures how much the average freshness time of chamomile changes under that condition.

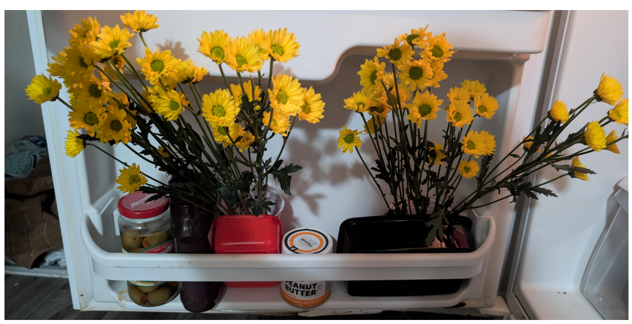

Figure 3: Setup of the `cold` condition for the `chamomile` experiment. Chamomile stems are stored in separate containers inside a household refrigerator, representing the `low temperature` treatment group. Each container holds a fixed number of stems, with equal water volume for the `water` subgroup.

2.2 Permutation Test

We employ permutation (randomization) tests, which align with the actual experimental design and do not rely on asymptotic approximations.

For each effect (`temperature`, `water`, and `interaction`), the procedure is:

1. Compute the observed difference in the mean (or median) `time-to-wilt` between the two relevant `chamomile groups`.

2. Randomly shuffle the `treatment labels` (e.g., cold vs. room, water vs. dry) many times (say, 10,000 permutations) while keeping the number of cups per group fixed.

3. For each shuffled dataset, recompute the `test statistic`.

4. The `p-value` is the fraction of permutations with a difference as or more extreme than the observed one.

2.3 Secondary Analyses

Linear Model. To summarize and interpret the factorial effects, we fit the regression model

$$Y_{ij} = \beta_0 + \beta_T T_j + \beta_W W_j + \beta_{TW} T_j W_j + \varepsilon_{ij}, \tag{2.1}$$

where $(\beta_T, \beta_W, \beta_{TW}$ estimate the three treatment effects.

Freshness and Bloom Scores. For each `chamomile stem`, we compute the average `freshness score` over time or the `area under the freshness curve`. These are analyzed using the same factorial structure or pairwise tests.

Visualization. We produce:

- Line plots of mean `freshness score` over time for each treatment group.
- Boxplots of `time-to-wilt` by temperature and water condition.
- Kaplan–Meier survival curves comparing `cold vs. room` and `water vs. dry` conditions.

2.4 Interpretation

A positive temperature effect ($\Delta_T > 0$) indicates that cold storage helps `chamomile` last longer. A positive water effect ($\Delta_W > 0$) means keeping `chamomile` in water improves freshness. A positive interaction ($\Delta_{TW} > 0$) suggests the benefits of cold and water reinforce each other.