Moisture

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Motivation

Importance and Challenges

- In post harvest processing, much mill loss is experienced in cracking and shelling.
- Higher percentage half yield will result in greater profits.
- Increased Demand in halves.
- Improved understanding of the role of moisture

Research Objective

- **Objective 1: Determine Optimal Moisturizing Conditions**
- **Objective 2: Develop Predictive Models**
- **Objective 3: Air Drying effect on Kernel and Shell moisture**

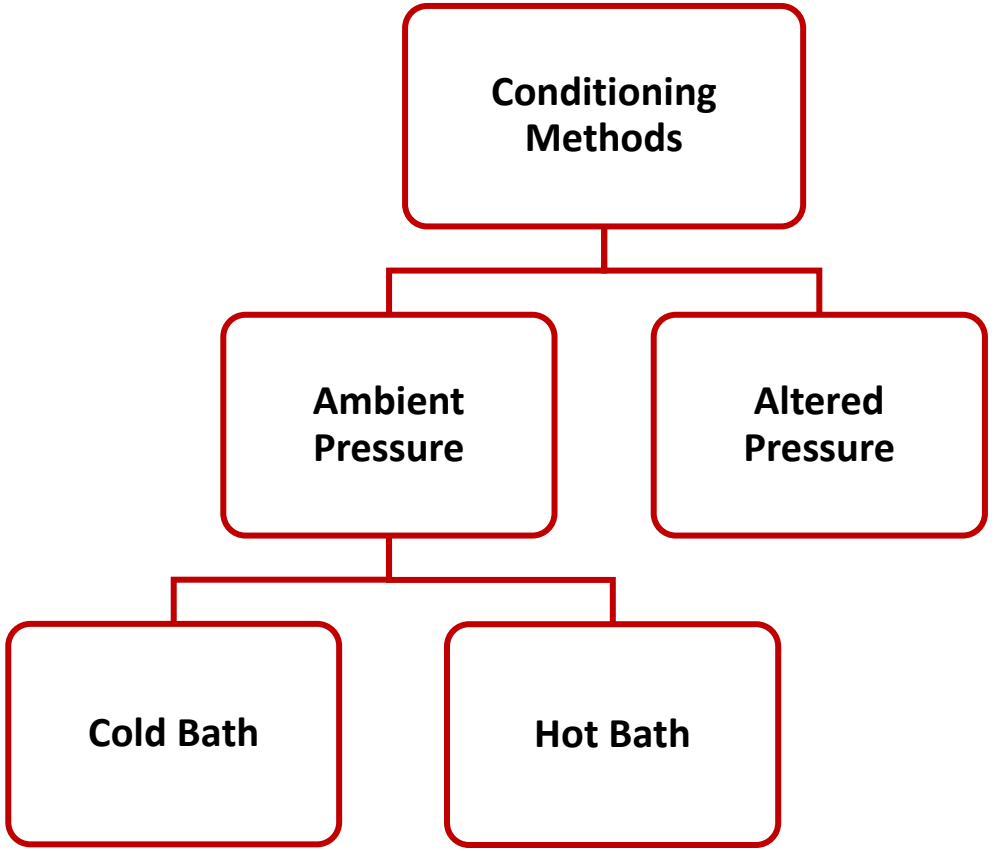
Equipment

Figure	Equipment	Description
	IR3000	Using near infrared sensor to monitor moisture content.
	Aqualab 3	Aqualab3 uses modular sensor block that contains a chilled-mirror dew point sensor and a capacitive hygrometer for precise measurements.

Equipment

Figure	Equipment	Description
	SB900	Secondary methods were developed wherein the electrical properties of pecans can be measured and converted into moisture content.
	Sous-Vide Precision Cooker	Heating the water to the certain temperature

Conditioning Methods



Conducted Studies

Small Batch Study

Cold Bath soaking methods

Hot Bath soaking methods

Large Batch Study

Cold Bath soaking methods

Small Batch Study

Cold Bath

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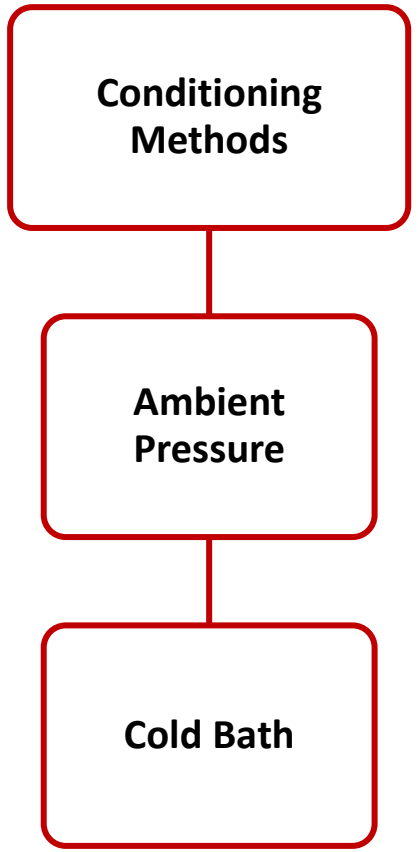
Cold Bath Method

Independent Variables	Unit	Levels	Dependent Variables	Unit
Initial Moisture	%	TBD	Post-Conditioning Moisture	%
Initial Temperature	°F	TBD		
Water Temperature	°F	70	Post-Conditioning Temperature	°F
Soaking Time	hr.	5,6,…,35		
Air Dry	Min.	10		
Pecan Variety	N/A	Stuarts / Desirables / TBD		

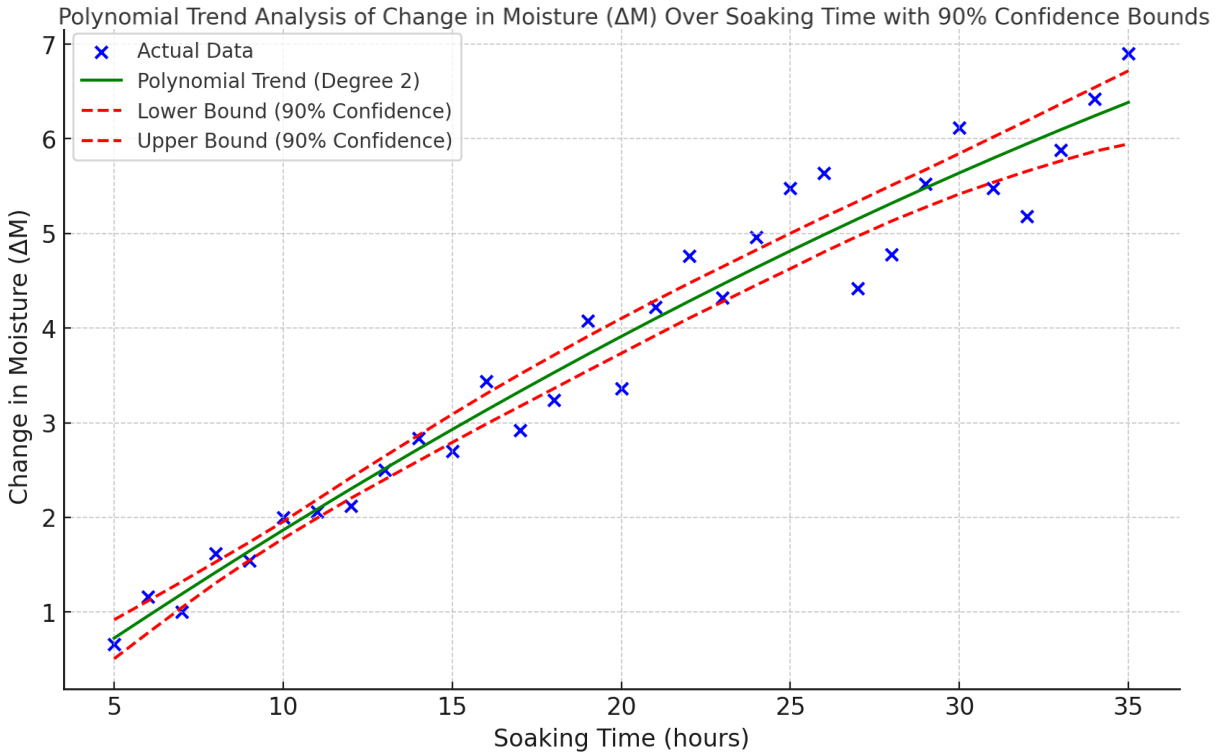


Cold Bath results

- **This equation indicates that ΔM changes with soaking time in a non-linear fashion.**

$$\Delta M = -0.0016 \times (t_s^{\,2}) + 0.2522 \times (t_s) - 0.4976$$

$$R^2 = 0.953$$



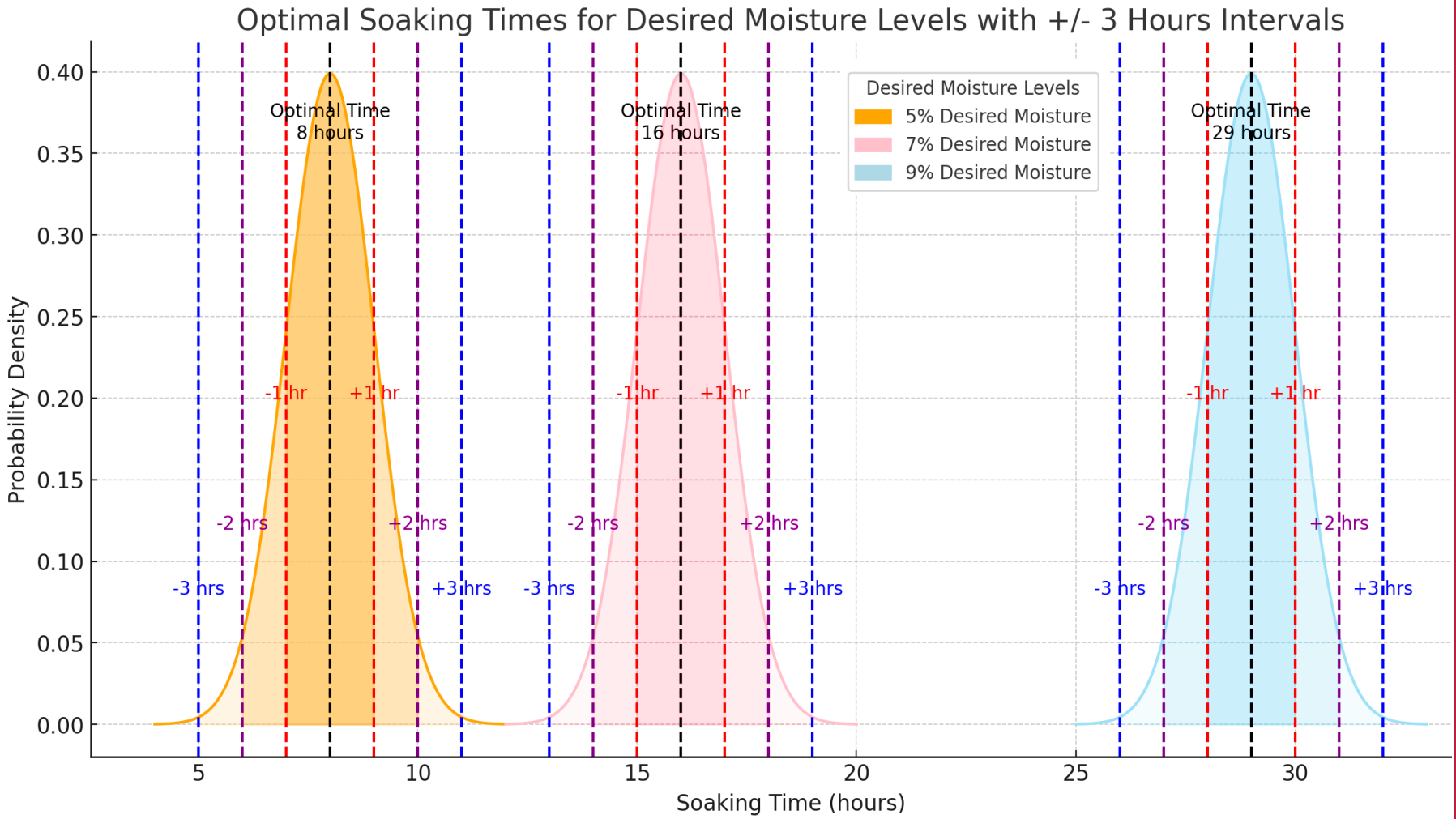
∗ t_s= Soaking time (hours)

Cold Bath takeaways

$$M_d = M_i + kt_s(T_b - T_p)$$

$$M_d \sim \aleph(M_i + kt(T_b - T_p), \sigma)$$

M_d = Desired Moisture Level
M_i = Initial Moisture Level
T_b = Temperature of Water Bath
T_p = Initial pecan temperature
t_s= Soaking time
k = moisture absorption factor in pecans which depends on a host of variables (per unit time and temperature)



Small Batch Study

Hot Bath

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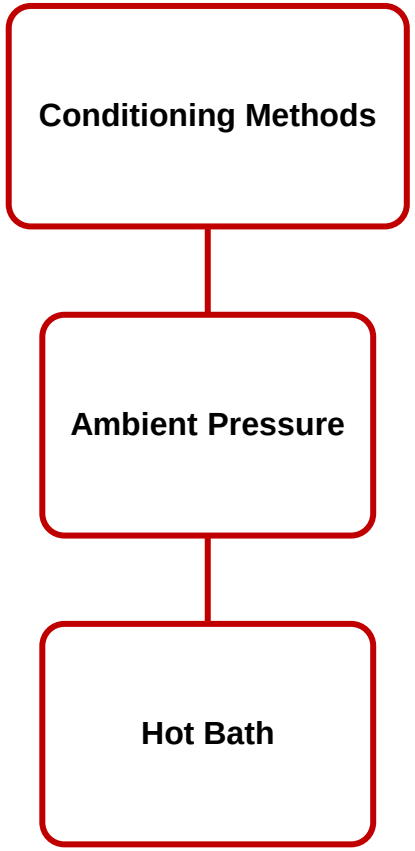
Hot Bath Methods

Independent Variables	Unit	Levels			Dependent Variables	Unit
Initial Moisture	%	TBD			Post-Conditioning Moisture	%
Initial Temperature	°F	TBD				
Water Temperature	°F	180, 185,…,200			Post-Conditioning Temperature	°F
Soaking Time	min.	5,10,…,20				
Air Dry	min.	10				
Repetition	NA	3				
Pecan Variety	N/A	Stuarts	Desirables	TBD		



Hot Bath results

- **Soaking Time ↑→ Changes in moisture content ↑**
- **Water Temperature ↑→ Changes in moisture content ↑**

$$180\,°\text{F}: \Delta M = -0.3050 + 0.638 \times t_s - 0.001 \times t_s^2$$

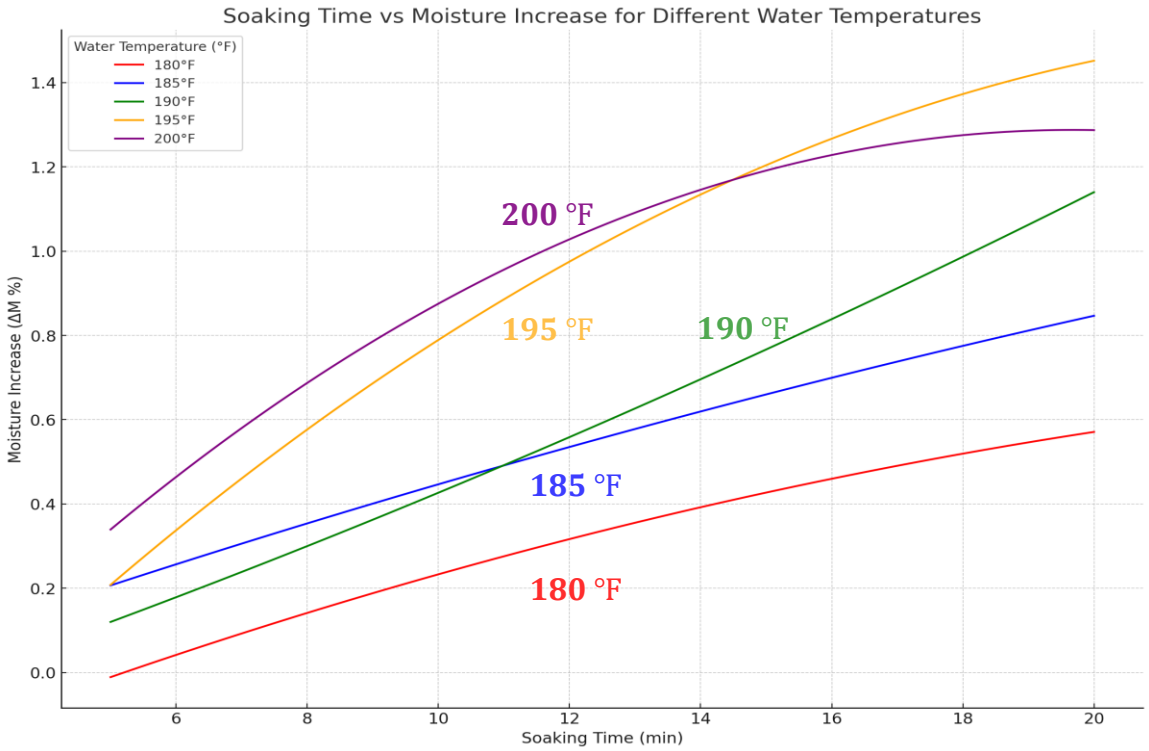
$$185\,°\text{F}: \Delta M = -0.0600 + 0.0560 \times t_s - 0.0005 \times t_s^2$$

$$190\,°\text{F}: \Delta M = -0.1533 + 0.0513 \times t_s + 0.0007 \times t_s^2$$

$$195\,°\text{F}: \Delta M = -0.5400 + 0.1663 \times t_s - 0.0033 \times t_s^2$$

$$200\,°\text{F}: \Delta M = -0.4167 + 0.1732 \times t_s - 0.0044 \times t_s^2$$

∗ T_b= Bath Temperature (°F)
∗ t_s= Soaking time (min)



Hot Bath takeaways

1. The change in moisture (ΔM) increases with soaking time.
2. Higher water temperatures result in greater changes in moisture content (ΔM).
3. The rate of increase in ΔM slows down at longer soaking times.
4. Post-conditioning moisture consistently increases with soaking time.
5. Post-conditioning moisture is higher at elevated water temperatures

Large Batch Study

Cold Bath

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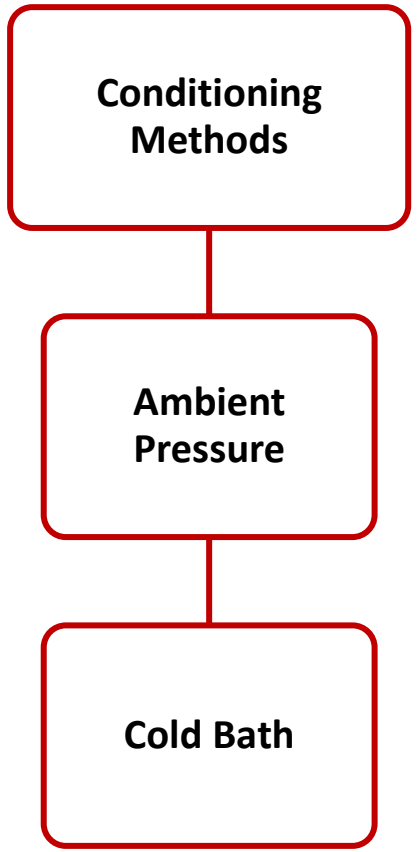
Cold Bath Method (Large Batch)

Independent Variables	Unit	Levels			Dependent Variables	Unit
Initial Moisture	%	TBD			Post-Conditioning Moisture	%
Initial Temperature	°F	TBD				
Water Temperature	°F	70			Post-Conditioning Temperature	°F
weight	Lbs.	90				
Soaking Time	hr.	6-10 14-18 26-31				
Air Dry	Min.	10				
Pecan Variety	N/A	Stuarts	Desirables	TBD		

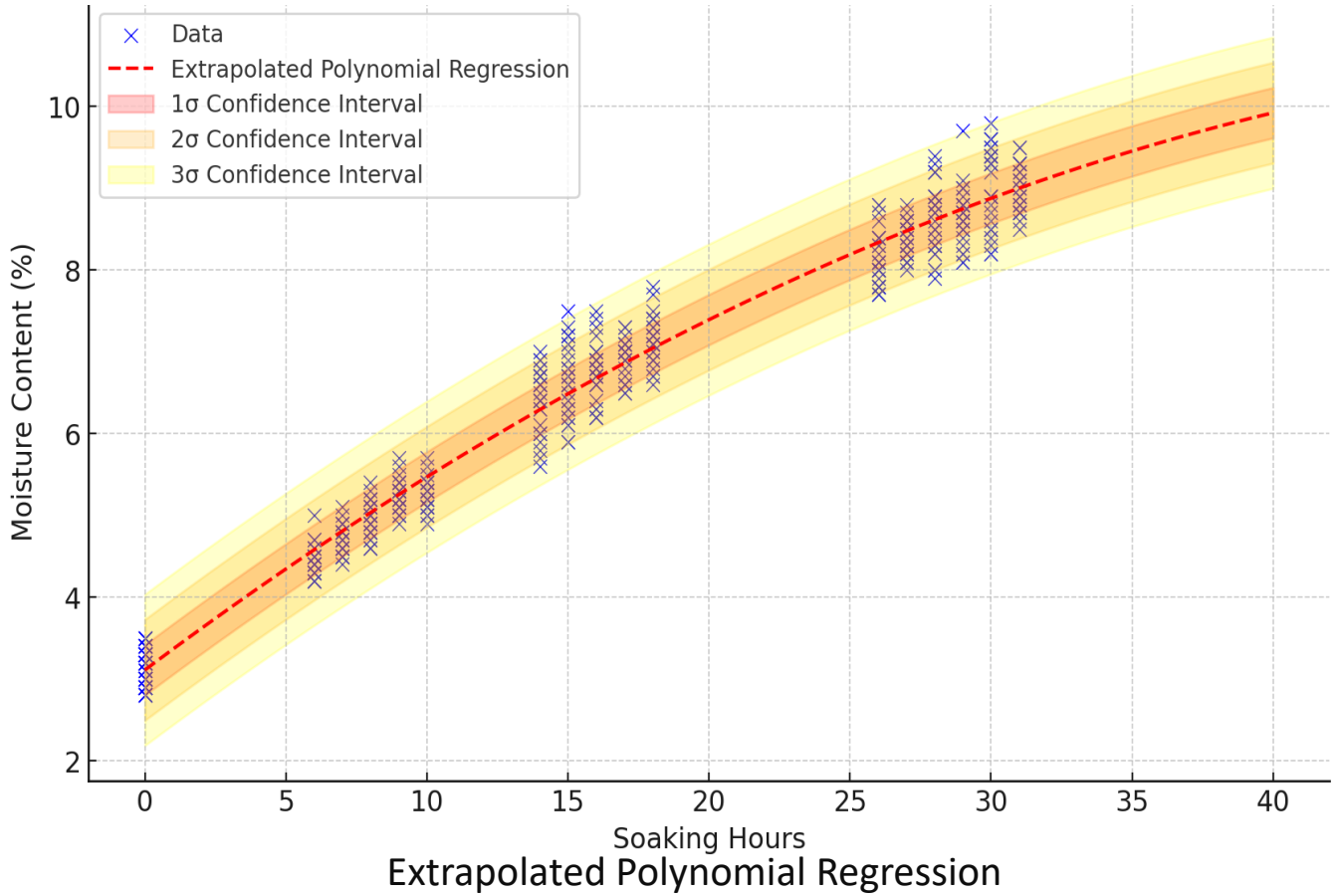


Large Batch results

- **Wider confidence intervals (especially at longer soaking hours) means the moisture content is less predictable at higher durations.**

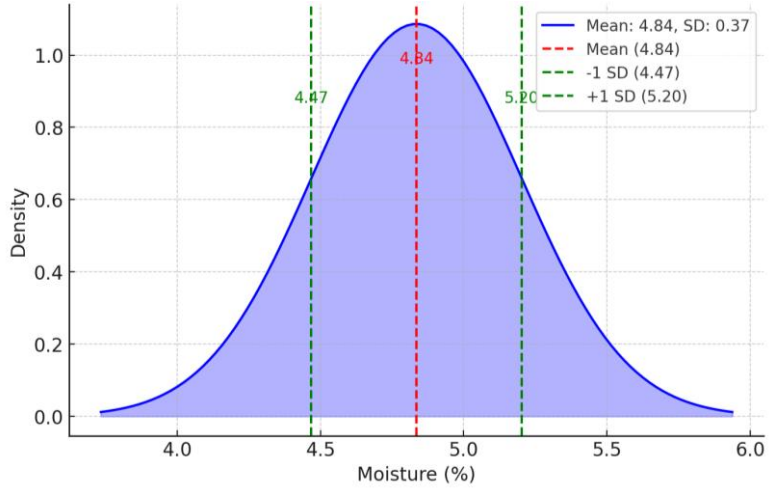
*Note: Data analysis for this study is in progress.

$$\textit{Moisture Content}\ (\%) = -0.0022 \times (t_s)^2 + 0.2580 \times (t_s) + 3.1089$$

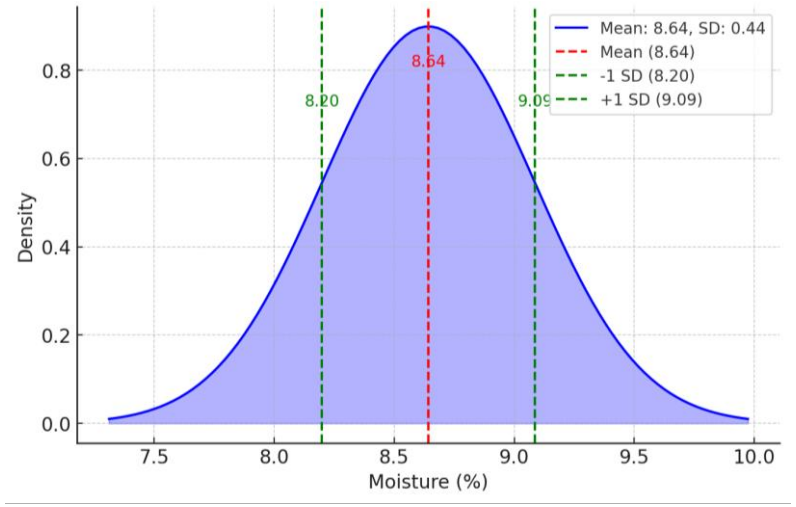


Large Batch Takeaways

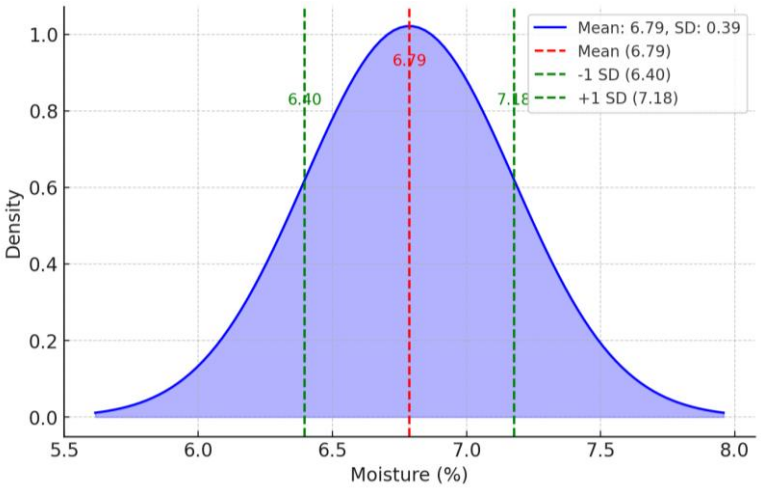
Moisture content	Soaking time (recommended time)
4.5-5.5%	6 – 10 hours



Moisture content	Soaking time (recommended time)
6.5-7.5%	14 – 18 hours



Moisture content	Soaking time (recommended time)
8.5-9.5%	27 – 31 hours



Recommendation

- Avoid high soaking Time because it causes noise.
- We hypothesize that the combination of cold and hot baths can be the optimal approach to reach the desired moisture level.
- Being reactive to the existing moisture level rather than trying to set the moisture to a certain level.

Next Steps

Experiment

Studying impact of air-drying on shell and kernel moisture

- **Purchasing required equipment (Done)**
- **Design of experiment and pilot study (In progress)**
- **Data Collection(Not Started)**
  - Using Oven and Infrared sensor to measure shell moisture content
  - Using Oven and Secondary methods to measure kernel moisture content

Investigating Negative pressure as a moisturization approach

- **Rebuilding the equipment (In progress)**
- **Design of Experiment and pilot study(Not Started)**
- **Data collection steps(Not Started)**

Publication

A Predictive Analysis of Pecan Moisture Content Using Cold and Hot Bath Soaking Methods (In Progress - Ready to Submit)

Air-Drying Effect on Shell and Kernel Moisture (Not Started)

Investigating Negative pressure as a moisturization approach (Not Started)