**Core Libraries for Data Handling and Numerical Computation**

**✅ pandas – *Data Manipulation and Analysis***

**Strength**:

* Powerful DataFrame structure for handling tabular data.
* Supports grouping, filtering, merging, and time-series indexing with ease.

**Suitability**:

* Enabled structured manipulation of agricultural sales records across multiple products.
* Facilitated seamless splitting into training and testing datasets by product and time.

**✅ numpy – *Numerical Computations and Array Handling***

**Strength**:

* Fast and memory-efficient operations on large arrays and matrices.
* Vectorized operations for statistical modeling.

**Suitability**:

* Used in efficient handling of time series data values.
* Supported matrix-based computations essential in forecasting and evaluation.

**✅ scipy.stats – *Statistical Tests and Distributions***

**Strength**:

* Comprehensive suite of statistical tests and probability distributions.
* Ideal for hypothesis testing and data distribution analysis.

**Suitability**:

* Played a key role in verifying assumptions such as normality and trend presence.
* Added scientific rigor to the pre-modeling phase (e.g., validating stationarity).

**📊 Visualization Libraries for Pattern Recognition**

**✅ matplotlib.pyplot – *Base Visualization Library***

**Strength**:

* Low-level plotting control for custom visualizations.
* Integration with other Python libraries like seaborn.

**Suitability**:

* Essential for line plots of quantity sold over time, seasonal trends, and residual analysis.
* Helped communicate insights with stakeholders through visual storytelling.

**✅ seaborn – *Advanced Statistical Data Visualization***

**Strength**:

* Simplifies complex plots with fewer lines of code.
* Comes with built-in themes for aesthetics and readability.

**Suitability**:

* Used for heatmaps, trend plots, and correlation matrices across agricultural products.
* Helped spot anomalies and seasonality in agricultural demand.

**🧠 Time Series Modeling and Analysis Libraries**

**✅ statsmodels.tsa.stattools.adfuller – *ADF Test for Stationarity***

**Strength**:

* Implements the Augmented Dickey-Fuller test to assess time series stationarity.
* Foundation for ARIMA model preparation.

**Suitability**:

* Crucial in preprocessing steps to determine whether differencing was needed before modeling.

**✅ statsmodels.tsa.arima.model.ARIMA – *ARIMA Model for Forecasting***

**Strength**:

* Classic model for univariate time series data.
* Captures autoregression (AR), integration (I), and moving average (MA) components.

**Suitability**:

* Provided reliable short-term forecasts for product demand trends.
* Well-suited for stable products with consistent seasonality and autocorrelation (e.g., Lettuce).

**✅ statsmodels.graphics.tsaplots – *ACF and PACF Plots***

**Strength**:

* Offers visual tools to identify lag patterns and determine ARIMA parameters.

**Suitability**:

* Supported model tuning by identifying optimal values of AR and MA components.
* Enhanced interpretability of temporal relationships in sales patterns.

**✅ prophet – *Facebook Prophet Model***

**Strength**:

* Handles seasonality, holidays, and trend shifts automatically.
* Built for business time series data that can be irregular or sparse.

**Suitability**:

* Excellent for agricultural products with seasonal spikes (e.g., Strawberries).
* Allowed daily-level forecasting and interpretability using trend and seasonality plots.

**🌲 Machine Learning Model**

**✅ sklearn.ensemble.RandomForestRegressor – *Random Forest for Regression***

**Strength**:

* Non-linear model that performs well on structured/tabular data.
* Automatically handles interactions and feature importance.

**Suitability**:

* Served as a strong benchmark for performance comparison.
* Useful in predicting demand where past sales may interact in complex, non-linear ways.

**📏 Evaluation Metrics for Model Accuracy**

**✅ sklearn.metrics – *Evaluation Functions (MAE, RMSE, MAPE)***

**Strength**:

* Standardized and reliable metrics to compare model performance.
* Compatible with both time series and regression outputs.

**Suitability**:

* Provided consistent evaluation across ARIMA, Prophet, and Random Forest models.
* Enabled identification of the best-performing model for each product.

**⚠️ warnings – *Suppressing Non-Critical Warnings***

**Strength**:

* Keeps the output clean and focused during batch modeling or iterative development.

**Suitability**:

* Ensured your modeling outputs remained readable and presentation-ready, especially when running multiple iterations of forecasting.

