FrischMarkt Expiry Loss Analysis: Executive Summary & Recommendations

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Project Title: Optimizing Fresh Food Inventory to Minimize Expiry Loss for FrischMarkt

1. Executive Summary

This report presents the findings and recommendations from a comprehensive data analysis project focused on understanding and mitigating fresh food expiry and markdown losses at FrischMarkt. Our analysis of 2023 operational data reveals that these combined losses are a significant financial burden, amounting to approximately **39.20% of total revenue**, or **€5,779,156.94** annually. This substantial leakage directly impacts profitability and threatens the long-term sustainability of the business.

Through the development of a data-driven demand forecasting model, we have identified key drivers of demand volatility and inventory discrepancies. This project outlines actionable strategies to transition FrischMarkt from reactive loss management to a proactive, optimized inventory system. By implementing the proposed recommendations, FrischMarkt can expect to achieve substantial cost savings, improve operational efficiency, and move towards a more financially stable future.

2. Project Objective

The primary objective of this project was to:

- Quantify the scale and specific areas of fresh food expiry and markdown losses across FrischMarkt operations.
- Identify the underlying drivers of demand fluctuations and inventory imbalances at a granular level.
- Develop robust demand forecasting models to inform precise, data-driven ordering decisions.
- Formulate actionable recommendations to minimize losses, reduce waste, and enhance FrischMarkt's overall profitability.

3. Key Findings

Our in-depth analysis of FrischMarkt's 2023 data revealed critical insights into the causes and patterns of fresh food losses:

3.1 Overall Loss Landscape

- **Total Annual Losses:** In 2023, FrischMarkt incurred **€5,779,156.94** in combined expiry and markdown losses, representing **39.20%** of its total revenue of **€14,740,876.17**.
- **Loss Composition:** Expiry losses (**€4,701,951.56**) significantly outweigh markdown losses (**€1,077,205.38**), indicating that a substantial portion of inventory is expiring before it can even be sold at a discount.

3.2 Loss Hotspots

- **Product Categories:** The highest losses are concentrated in the **"Fleisch" (Meat), "Frischware" (Fresh Produce), and "Backwaren" (Baked Goods)** categories, collectively accounting for the vast majority of total losses.
- **Top Products:** "Rinderhackfleisch" (Beef Mince), across its different product IDs, cumulatively represents the single largest overall loss driver, with a combined total loss (expiry + markdown) exceeding **€1.3 million**. It is closely followed by "Erdbeeren" (Strawberries) and "Schweinekoteletts" (Pork Chops), both with combined total losses exceeding **€600,000**. Other high-loss items include "Äpfel Elstar," "Vollkornbrot," "Leberwurst," "Sonntagsbrötchen," "Bananen," "Weißbrot," and "Kartoffelsalat."
    - ***Insight**:* For these products, expiry loss is the overwhelming component, indicating that current markdown strategies are not effectively intercepting spoilage.
- **Store Performance: "FrischMarkt Kreuzberg"** and **"FrischMarkt Prenzlauer Berg"** are the stores with the highest total losses (each nearing €2.0 million).
- **Management Quality Impact:** Stores categorized with **"Poor" management quality** exhibit the highest average expiry rate (over 40%), significantly higher than "Excellent" (24%) or "Good" (30%) quality stores. This highlights a direct correlation between operational management and waste.

3.3 Demand Forecasting Model Insights

Our Demand Forecasting Model, built using a RandomForest Regressor, achieved an **R-squared (R2) score of 0.6789** and a **Mean Absolute Error (MAE) of 11.97 units**. This indicates that the model explains a substantial portion of demand variability and provides a reasonable average prediction error, especially considering the volatility of perishable goods. The Mean Absolute Percentage Error (MAPE) was 38.18%.

Key drivers of units sold (demand) as identified by the model's feature importances include:

- **Inventory Availability:** `received_inventory` (0.487) and `beginning_inventory` (0.204) are overwhelmingly the most dominant factors. This strongly suggests that sales are heavily influenced by the sheer volume of product available, indicating potential overstocking driving both sales and subsequent expiry.
- **Lagged Sales & Recent Trends:** Past sales patterns (`units_sold_lag1` (0.032), `rolling_mean_sales_7d` (0.026), `units_sold_lag7` (0.015), `units_sold_lag30` (0.012)) are highly predictive of future demand, capturing short-term trends and weekly cycles.
- **Product Characteristics:** `shelf_life_days` (0.072) and `profit_margin` (0.016) also play a significant role, highlighting the inherent perishability and economic value of products.
- **Seasonality:** Time-based features such as `day_of_week_num` (0.014, 0.013) and `day_of_week_Saturday` (0.010) play a consistent role, confirming predictable fluctuations in demand based on the day of the week.
- **External Factors:** `temperature_high_c` (0.009) and `temperature_low_c` (0.007) demonstrate that environmental conditions also influence demand, particularly for temperature-sensitive items.
- **Base Expiry Rate:** `base_expiry_rate` (0.007) also contributes to the model's understanding of demand.

4. Strategic Recommendations

Based on these critical findings, we propose the following data-driven strategies to minimize FrischMarkt's expiry loss and enhance its profitability:

4.1 Implement a Granular Demand-Driven Ordering System

- **Recommendation:** Develop and integrate an automated ordering system that leverages the demand forecasting model's predictions. This system should generate daily or weekly order recommendations for each product at each store, dynamically adjusting quantities based on forecasted sales, product-specific shelf life, and current inventory levels.
- **Action Plan:**
    - **Phase 1 (Pilot):** Roll out the new ordering system for the top 5 high-loss products (e.g., "Rinderhackfleisch," "Erdbeeren," "Schweinekoteletts") in the highest-loss stores ("FrischMarkt Kreuzberg," "FrischMarkt Prenzlauer Berg").
    - **Phase 2 (Expansion):** Gradually expand to more products and stores, refining the model and processes based on pilot results.
- **Quantified Impact (Estimate):** By reducing overstocking and aligning inventory more precisely with demand, we estimate a **10-15% reduction in current expiry losses**, potentially saving FrischMarkt an additional **€500,000 - €800,000 annually** from the expiry component alone.

4.2 Optimize Markdown Strategies with Forecasting Input

- **Recommendation:** Re-evaluate and refine current markdown strategies. While "Aggressive" markdowns lead to high markdown loss, "Conservative" markdowns appear insufficient. Implement a more dynamic, rules-based markdown system for products nearing expiry, informed by forecasted demand and remaining shelf life. For example, trigger earlier, targeted discounts for high-risk items when the forecast indicates low demand.
- **Action Plan:**
    - Develop clear, data-informed guidelines for store managers on markdown timing and depth.
    - Focus on converting at-risk inventory into sales before it becomes a complete expiry loss.
- **Quantified Impact (Estimate):** More effective and timely markdowns could lead to an additional **€200,000 - €400,000** in recovered revenue annually from items that would otherwise expire completely.

4.3 Enhance Operational Excellence and Supplier Review

- **Recommendation:** Address the human and process factors contributing to losses, particularly in stores with lower management quality. Simultaneously, establish a process for reviewing and optimizing supplier performance.
- **Action Plan:**
    - **Targeted Training:** Implement mandatory training programs for store staff, especially in "Poor" and "Average" management quality stores, focusing on best practices for perishable inventory management, stock rotation (FIFO), and proper storage.
    - **Performance Monitoring:** Establish and regularly review KPIs for stock rotation efficiency and expiry rates at the store level.
    - **Supplier Collaboration:** Prioritize suppliers who consistently deliver products with longer actual shelf lives and fewer delays, especially for high-risk products like "Erdbeeren" and "Rinderhackfleisch."
- **Quantified Impact (Estimate):** Improved operational efficiency and supplier quality are projected to reduce overall expiry losses by an additional **5-8%**, translating to **€250,000 - €450,000 annually**, complementing the gains from demand forecasting.

5. Conclusion & Roadmap

FrischMarkt faces a significant challenge with fresh food losses, but this analysis provides a clear, data-driven pathway to recovery. By embracing a robust demand forecasting model for inventory optimization and supplementing it with refined markdown strategies and operational improvements, the business can dramatically reduce its financial leakage.

The recommended strategies form a roadmap for sustainable growth:

1. **Pilot and Scale** the demand-driven ordering system, starting with top loss products and stores.
2. **Iterate and Refine** markdown strategies based on real-world impact.
3. **Invest in Training** and foster a culture of data-informed decision-making across all store operations.
4. **Continuously Monitor** model performance and adjust based on new data and evolving market dynamics.

Implementing these recommendations will not only stem the substantial losses but also enhance FrischMarkt's competitiveness, improve fresh product availability for customers, and build a more resilient and profitable retail operation.