Pistachio Processing for Paramount Farms

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Biological Systems Engineering

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Problem Statement

Over the past several years pistachios have become a popular snacking choice. Pistachios, although delicious, can harbor unwanted microbial contaminants. In recent years, sickness from eating improperly processed pistachios has been in the news. Paramount Farms would like to improve their process to be more efficient and reduce the number of sicknesses.

Constraints and Criteria

- Plan and execute plant visit and maintain open communication with client
- Maintain current sensory parameters used by Paramount Farms
- Achieve a 4-log microbial reduction to ensure product safety
- Develop a working HACCP plan for the facility

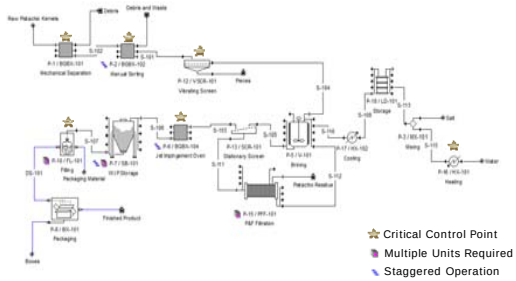
Standards

- **Good Manufacturing Practices (GMP)**
  - Monitored and enforced by FDA
- **USDA: United States Standards for Grades of Shelled Pistachio Nuts**
  - Determined acceptable levels of kernel damage and foreign material in final product
- **Grocery Manufacturers Association (GMA) – Control of *Salmonella* in low moisture foods**
  - Correct handling of foods contaminated with *Salmonella*
  - Heat resistance of *Salmonella*
- **Hazard Analysis and Critical Control Points (HACCP)**
  - Identify points of vulnerability to contaminants hazards in the process
  - Create a plan to mitigate the hazard

Design Alternatives

Oven Technology	Pros	Cons
Traditional Oven	• Current method of roasting • Cheap equipment and operating costs	• Slow process time
Far-Infrared Oven	• Heat is targeted on pistachio	• High equipment and operating costs • Uneven roasting
Rotary Drum Oven	• Cheap equipment and operating costs • Common in food processing	• Harsh on pistachio kernels
Jet Impingement Oven	• Quick processing time • Similar to traditional oven • Even roasting	• More expensive than traditional oven

Process Design



Proof of Concept

Microbial Reduction

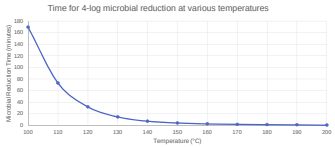
Formula Method by Ball (1923) according to Food Preservation Process Design (Heldman, 2011)

Assumptions:

Pistachios are spherical
Initial microbial count = $3x10^2$ microbes/g (Sejiny, Thabet, and Elshaieb, 1989)
Radius of kernel= 0.003175 m
4-log Reduction, D = 0.85 min at 121°C, Z = 27°C

Equation:

$$time_{process} = f_h * \log(\frac{j_c * (T_M - T_o)}{g})$$



Drying

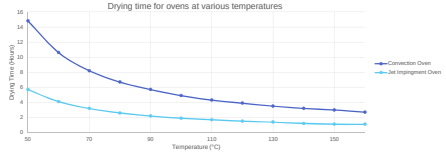
Transport Processes and Separation Process Principles 4th ed. (Geankoplis, 2003)

Assumptions:

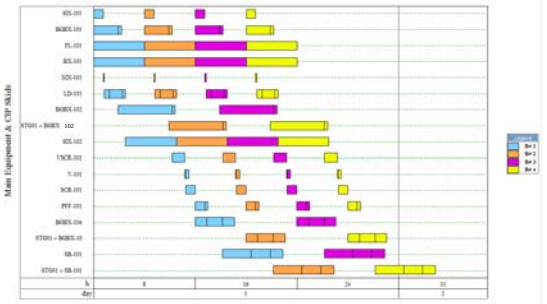
Convection Oven: Convective heat transfer coefficient 40 W/m²K
Jet Impingement: Convective heat transfer coefficient 120 W/m²K
Emissivity = 0.85, Equal heat transfer on all sides

$$R_c = \frac{(h_c + U_k)(T - T_s) + h_r(T_r - T_s)}{\lambda}$$

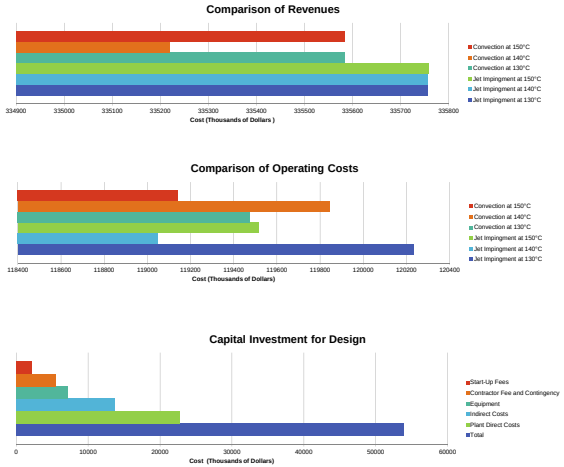
$$T_{dry} = \frac{1}{R_c} * m_{water\_removed} * m_{pistachio}$$



Plant Scheduling



Cost Analysis



Conclusions

The design team was able to create a working process flow diagram using SuperPro Designer. The process included both mechanical and manual sorting, the creation of a saltwater brine solution, brining, roasting, and packaging of pistachios into individual containers. Based on food processing and economic calculations, the final design involves a **jet-impingement oven operating at 140°C for 74.5 minutes** to attain the desired microbial reduction and final moisture content. The process time for one batch is 14.9 hours. The initial capital costs for the plant are $53,937,000 and the **payback period was approximately 5 months** with a net profit of $216,708,000 per year. Hazard analysis was implemented for the mechanical sorting, manual sorting, vibrating sorter, heat exchanger, oven, and filling steps.