Economic Analysis & Optimization of Sausage Production

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Introduction

For our capstone project we have chosen to work in conjunction with Sara Lee's Hillshire Farm brand on the production of co-extruded smoked sausage. We analyzed each unit operation in the processing of loop sausage from the final meat blend to final packaging.

Objectives

- Complete detailed review of sausage production process.
- Develop Plackett-Burman experimental design.
- Determine if temperature of brine bath, smoking tower, and cook in package processes are significant.
- Develop performance curves for brine temperature vs. dewatering.
- Complete economic analysis of plant process.

Process Operations

Meat Blending
Meat and non-meat ingredients blended for desired specific sausage formulations.

Meat grinding /Meat pumping
Meat is moved to the grinder by a pump and ground again to a finer consistency.

Co-extrusion/Stuffing
Continuous flow of meat blend is simultaneously co-extruded with collagen to create casing and sausage.

Brine Bath
Reduce the water content of the collagen gel casing by pushing strand of sausage material though a salt bath.

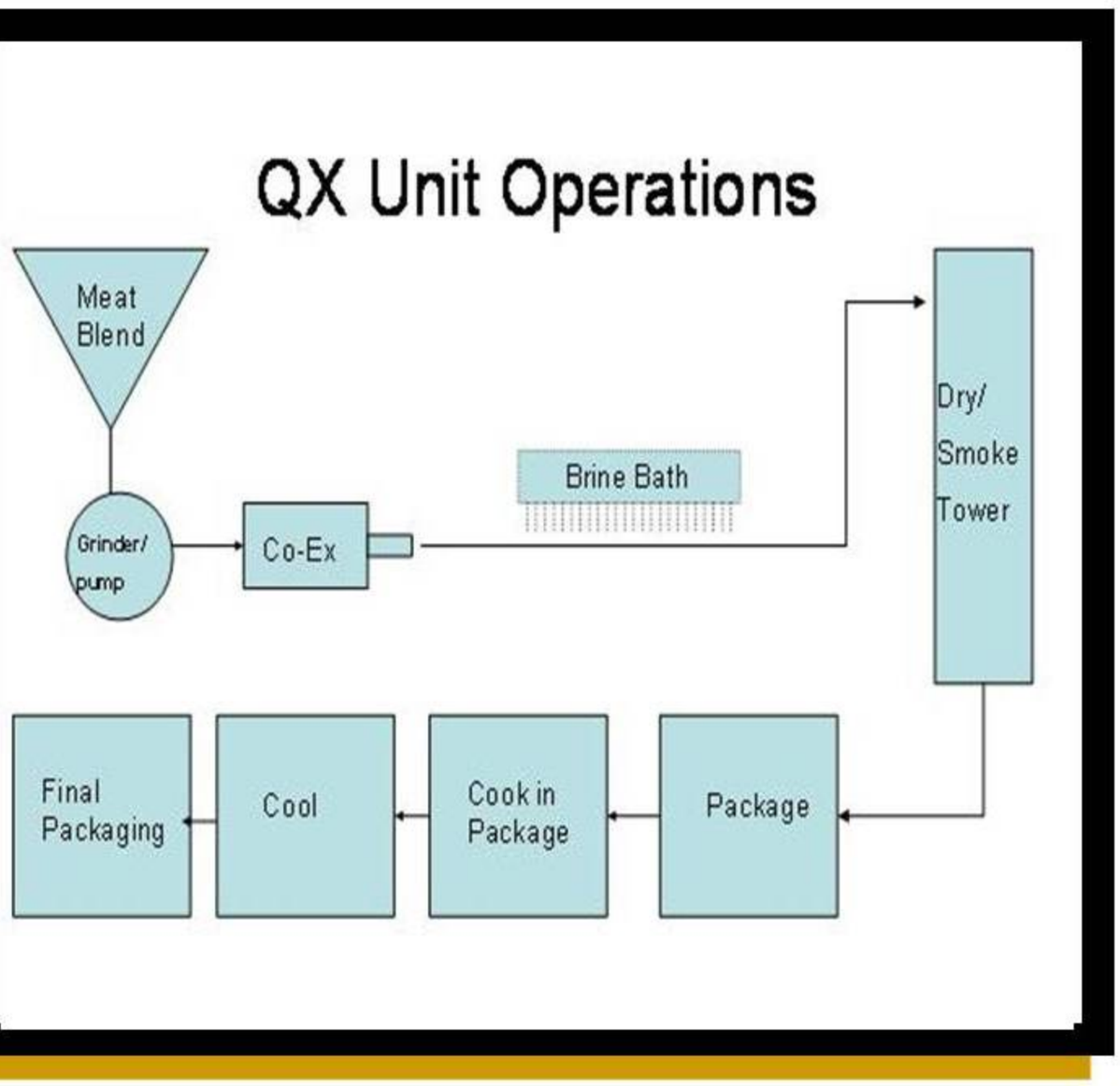
Smoke Tower/ Drying
Dry and cure meat, impart flavors and aroma, cook the sausage product, and cross link proteins in collagen gel.

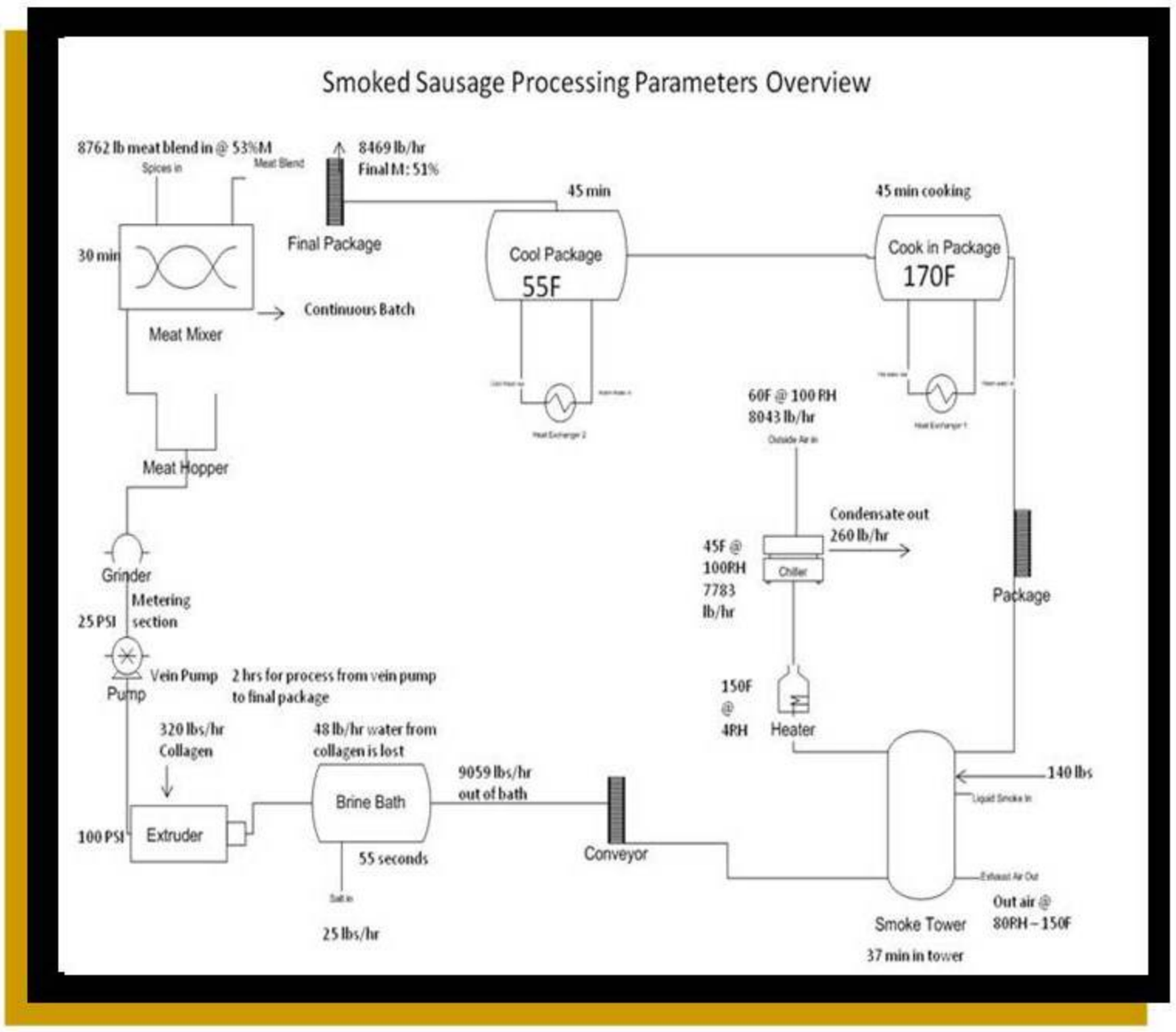
Primary Packaging
Partially cooked links are packaged into gas impermeable individual packages.

Cook-in Package
Final cooking of product in package submerged in hot water baths.

Cooling
Package links are cooled in a cold water bath to ambient temperature present in the sausage.

Final packaging
Final product packaged into boxes for distribution.



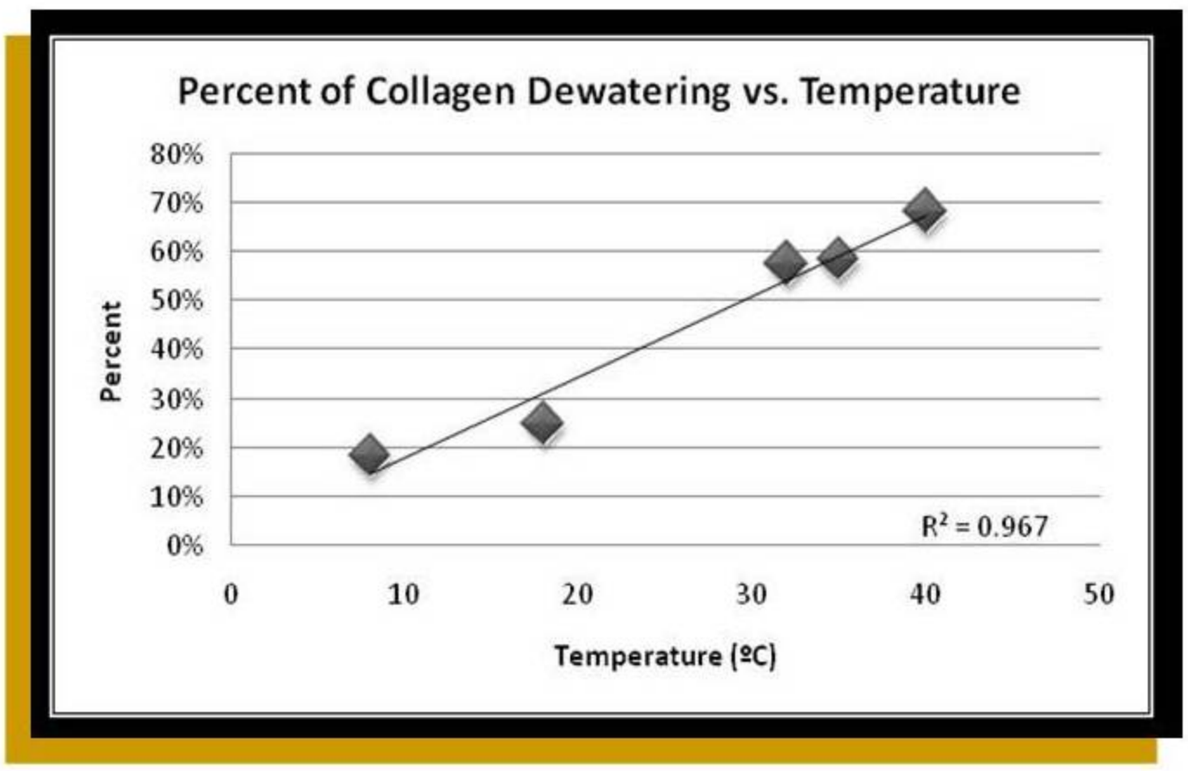


Experimental Designs

Performance Curves

Collagen Experiment Overview

- Analyze the effects of the brine bath solution on the amount of collagen dewatering on the casing of smoked sausage.
- Experiment by making collagen film and submerging it into bath solution at different temperatures using two brine solutions.



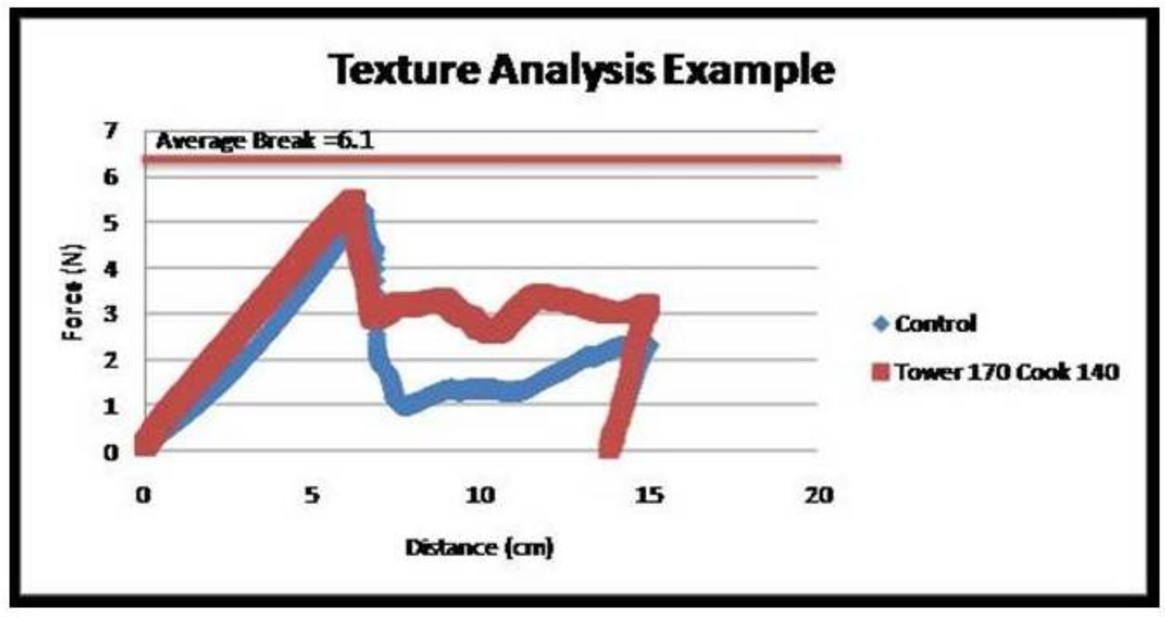
Plackett-Burman Design of Experiments

Our Sara Lee representative felt the major components for optimization include the smoke tower temperature (A) and the cook temperature (B).

The Design of Experiments

- Two dummy variables used to calculate error
- Tested two qualities to measure the significance of variables.
  - Moisture content
  - Break force (used to measure texture)
- The following is the analysis of our design of experiments.

Design of Experiments Texture Analysis Results



Effects and Significance

Results

- Smoke tower temperature and the cooking temperature are only significant to a 75% level.
- Experimental design set up where only variables at 95% would be considered significant.
- Variables chosen not significant and changing these factors had little to no effect on our two measured qualities, moisture and texture.
- Since the significance was very low and trials were all repeated we feel that this is an accurate conclusion.
- Using this data, we can contact our Sara Lee representative and prove that temperatures are not major factors that influence sausage moisture content and texture.

Acknowledgements: We would like to thank the ABE Dept, Prof. Okos, and Sara Lee for their guidance and help throughout our entire design.

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Economics

Total Product Investment (TPI) & Total Product Cost (TCI)

Breakdown of all the factors used to estimate Total Product Investment and Total Product Cost.

Plant Estimates (FCI)	Costs	
Total Equipment Cost	$	1,330,618
Purchased Equipment Installed	$	479,022
Instrumentation (Installed)	$	532,247
Piping (Installed)	$	425,798
Electrical (Installed)	$	266,124
Buildings (Services Included)	$	266,124
Yard Improvements	$	106,449
Service Facilities (Installed)	$	798,371
Engineering and Supervision	$	425,798
Construction	$	532,247
Legal	$	106,449
Contractor	$	106,449
Contingency	$	425,798
Total	$	5,801,495

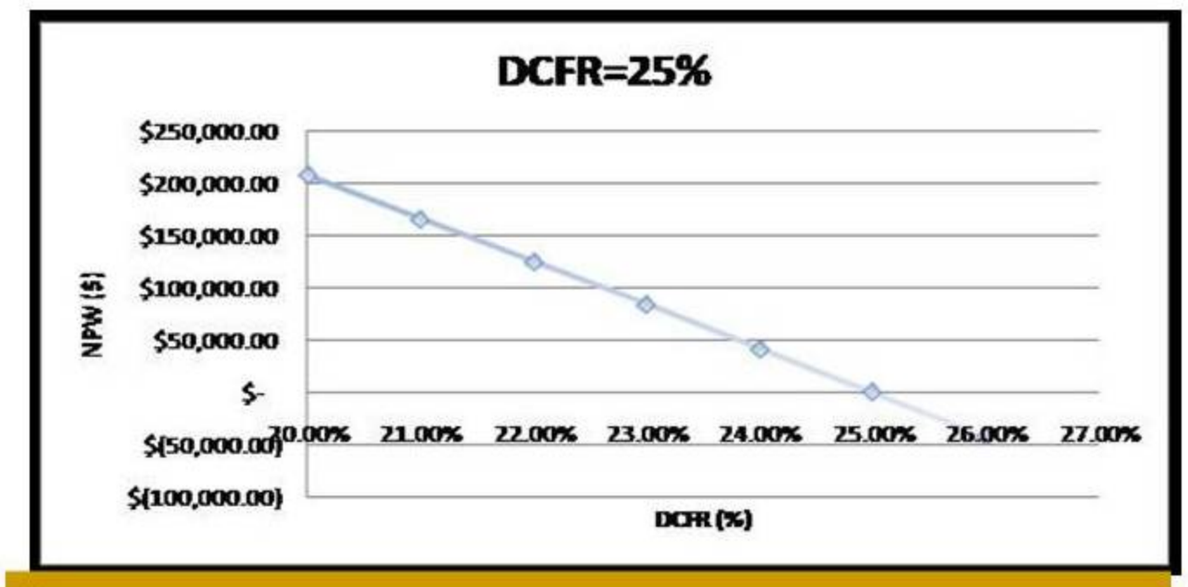
Component		Amount (lbs)	Cost/lb	Cost / Year
FCI*				$ 5,801,494.54
Major Raw Materials	Pork**	62,745,127.20	$ 0.60	$ 37,647,076.32
	Collagen	2,561,025.60	$ 0.10	$ 256,102.56
	Spices	640,256.40	$ 1.00	$ 640,256.40
Utilities***	Labor			$ 1,841,760.00
	Labor Supervision			$ 637,200.00
	Water			$ 7,075.94
	Electricity			$ 182,680.23
	Natural Gas			$ 5,443.20
Other	Maintenance	7%	of FCI	$ 406,104.62
	Operating Supplies	15%	of maintenance	$ 60,915.69
	Lab Charges	15%	of labor	$ 371,844.00
	Taxes	2%	of FCI	$ 116,029.89
	Insurance	1%	of FCI	$ 58,014.95
	Packaging	5%	of total cost	$ 2,111,525.19
			TCI:	$ 44,342,028.99
			Total Cost / lb	$ 0.69

* See equipment and plant estimates for further breakdown
** Pork cost/lb from pork commodity price
*** See process requirements for further breakdown

Discounted Cash Flow Rate (DCFR)

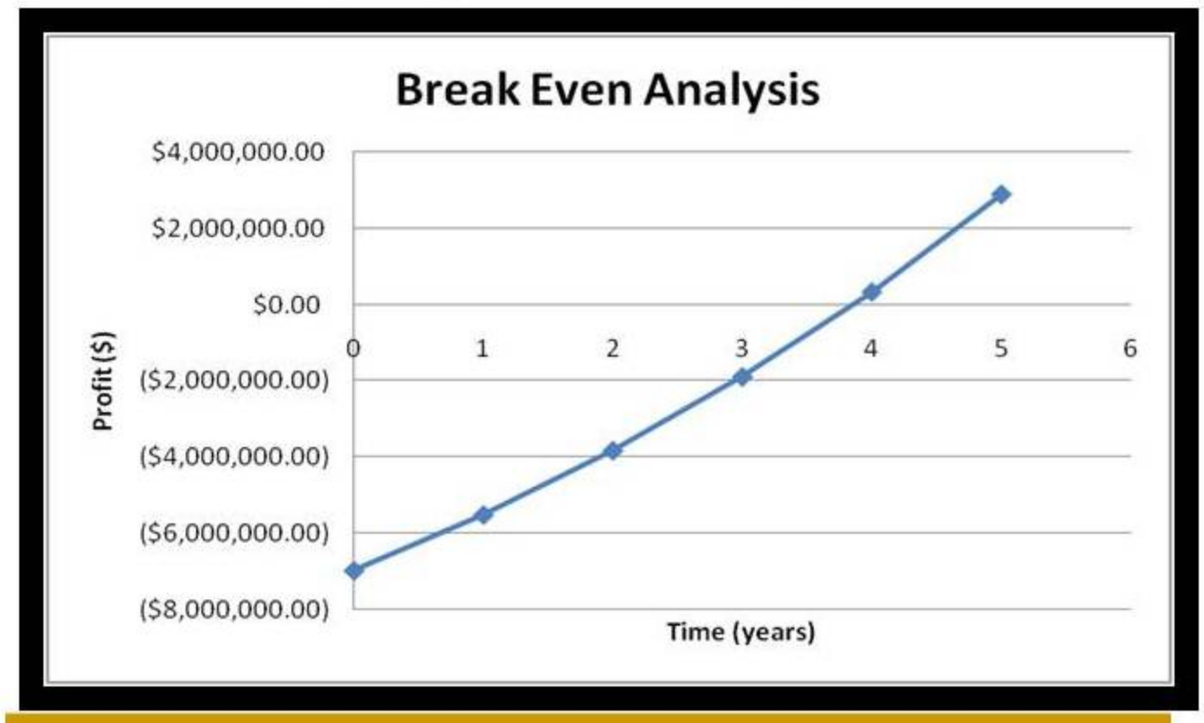
Parameters

- 40% tax,
- Sales price of $3.00 per sausage
- 25% margin for company as well as depreciation of equipment purchase costs
- Discounted cash flow rate is about 25%



Break Even Point

- Same parameters as DCFR
- Break even point just less than 4 years



Future Work & Recommendations

- Use performance cures to find savings for utilities.
- Calculate DCFR for each parameter.
- Choose optimal conditions by using DCFR.

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