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Project CARS: Causation And Reduction of Shrink

Pitt IE Team

Rahul Bidanda
Project Lead

Andrew DiPalma
Communications Lead

Ryan Fossick
Administrative Lead

Dan Denoncour
Data Analysis Co-Lead

Spencer Zacher
Data Analysis Co-Lead

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THE CLIENT

Perfection Pet Foods (PPF) is an extruded dry pet food and baked biscuit manufacturer in Visalia, CA.

They produce a private label for retailers and contract manufacturing for brand owners.

Their facility is state-of-the-art with a significant focus on food safety.

PROBLEM STATEMENT

HIGH YIELD LOSS (SHRINK)

Perfection Pet Foods (PPF) has seen higher shrink than expected on Kibble

PROBLEM STATEMENT

The variables that cause shrink in kibble are unknown and PPF is unable to control or reduce shrink

SYSTEMIC EFFECTS

- Total loss in end product
- Decrease in profit
- Decrease in capacity
- Disrupted scheduling

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SCOPE

In Scope

- Dog & Cat Kibble
- Batch Sizing
- Determine Causes of Shrink
- Analyze Formula sequencing
- Data 2019-Present

Out of Scope

- Biscuit Manufacturing
- Facility Layout
- Cost Savings Calculations
- Data before 2019

PROJECT GOALS

- Identify possible causal vairables
- Determine variables' impact on shrink
- Develop tools to optimize shrink
- Enable client to understand and control shrink

- Design a solution using both quantitative and qualitative methods
- Use a comprehensive approach that integrates Pitt's IE Curriculum
- Develop Leadership, Teamwork, and Project Management skillsets
- Refine Presentation, Communication, and Professional skillsets

PROJECT METRICS

Currently averaging 13.5% shrink

Target of average 7% shrink

SOLUTION METHODOLOGY

DEFINE
Outline the problem and define scope.

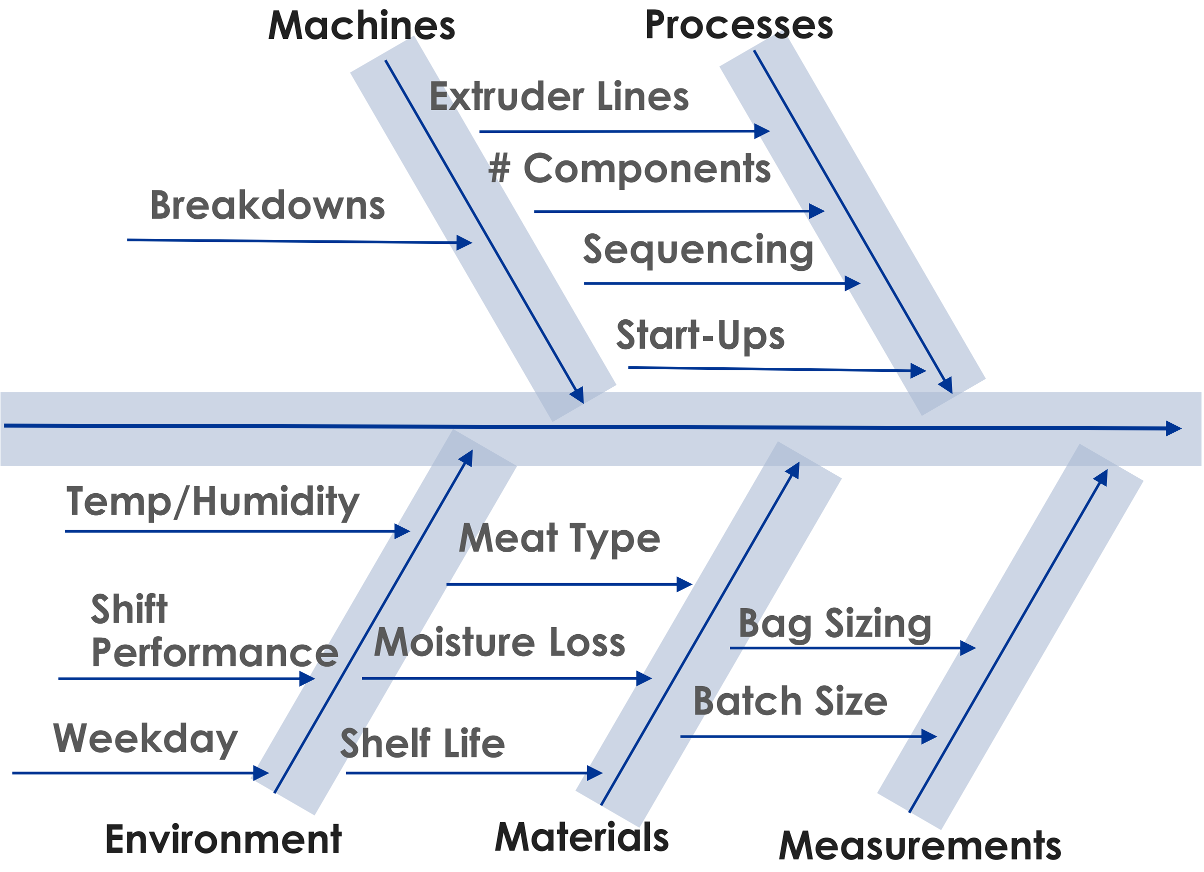
MEASURE
Data collection and orginization

ANALYZE
Process data with Excel and Minitab

IMPROVE AND CONTROL
Discuss results with client, provide recommendations

REPORT
Finalize suggestions and develop report and presentation

FISHBONE DIAGRAM



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DATA GATHERING

STAGE 1

- Data provided was reviewed
- Additional data was requested
- Additional data on extruders, breakdowns, scheduling, ingredients, etc. was reviewed

STAGE 2

To conduct a multivariate analysis, an attempt at combining data sets was started.

The Run ID was the best unique identifier

STAGE 3

A “Pseudo Run ID” was developed for datasets without Run ID. This helped combine some of related data.

Ex. WLDKN310-4/22/2020

SOLUTION TOOLS

SOFTWARE TOOLS

Excel
Access
Minitab
VBA & Macros

STATISTICS

ANOVA
Regression
Correalation
Tukey's Tests

VISUALIZATIONS

Box Blots
Histograms
Confidence Intervals
Pivot Charts and Tables

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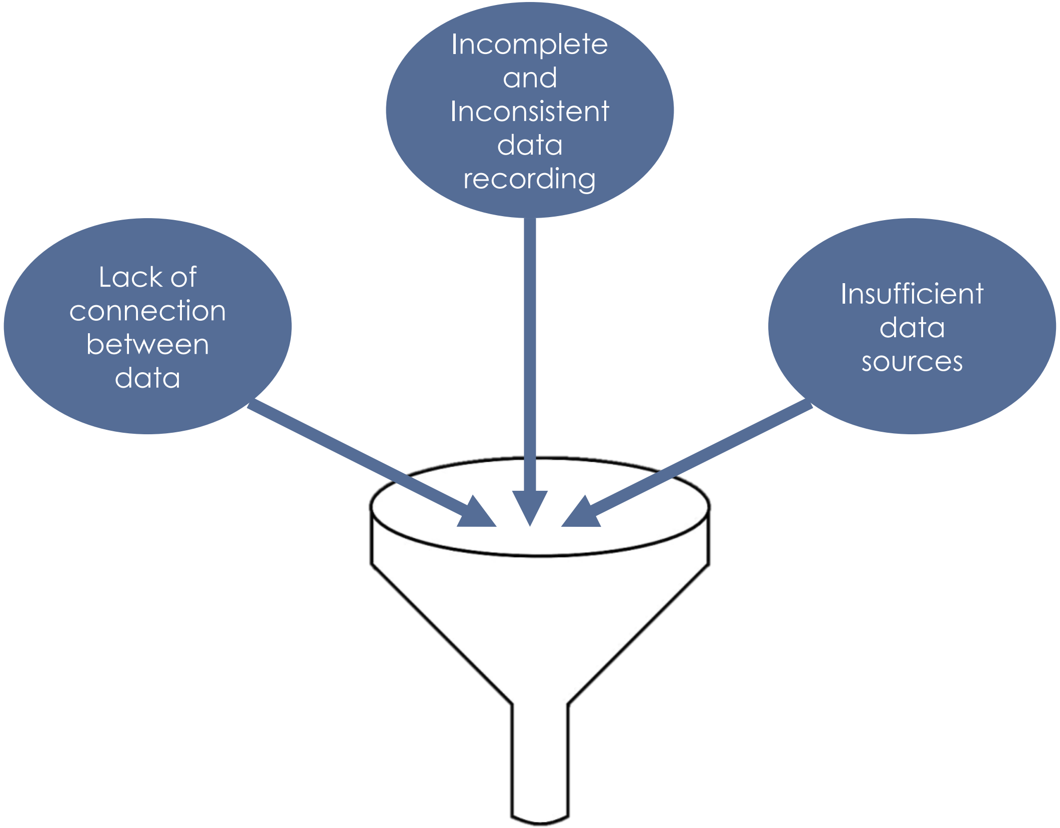
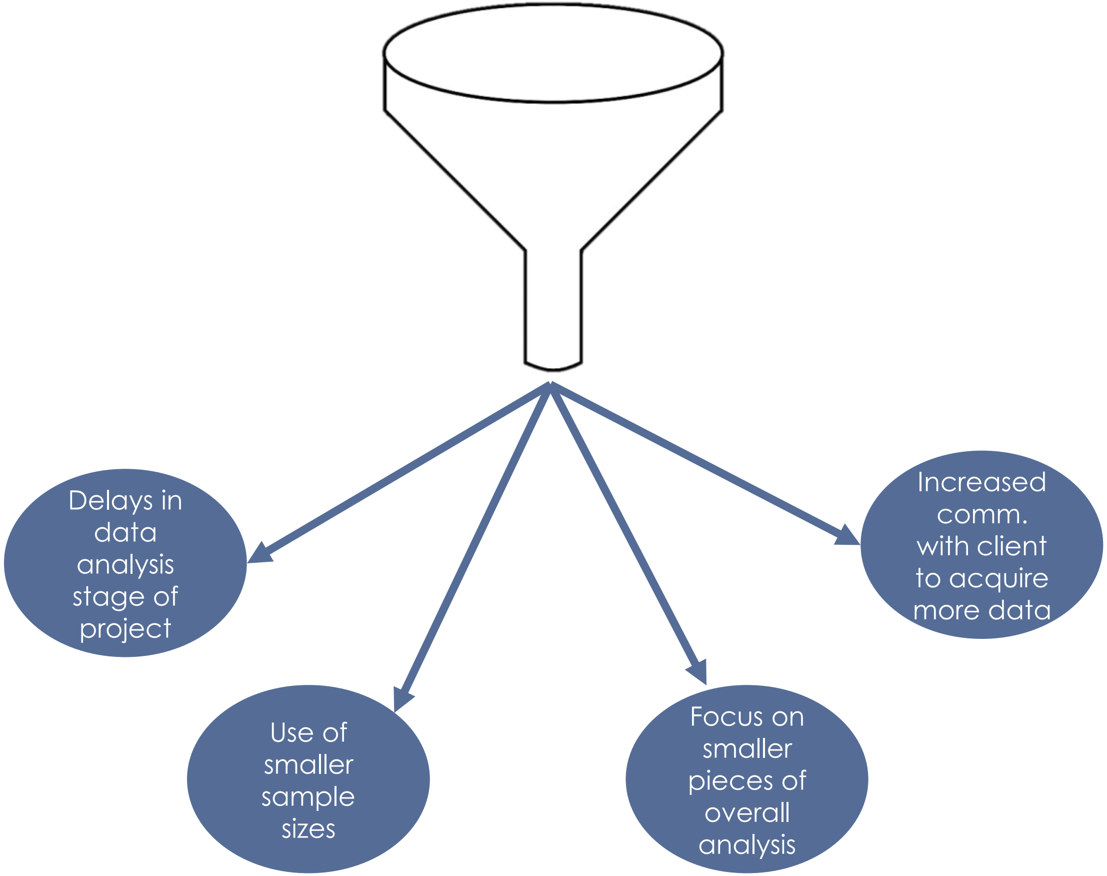
RISKS AND BARRIERS

Risk	Mitigation
Lack of in person communication	Weekly Zoom Calls Increased Communication Impromptu Zoom Calls
No knowledge of facility layout	Possible virtual tour, but this did not play a factor
Project delayed or off schedule	Adhere to Project Management Documents

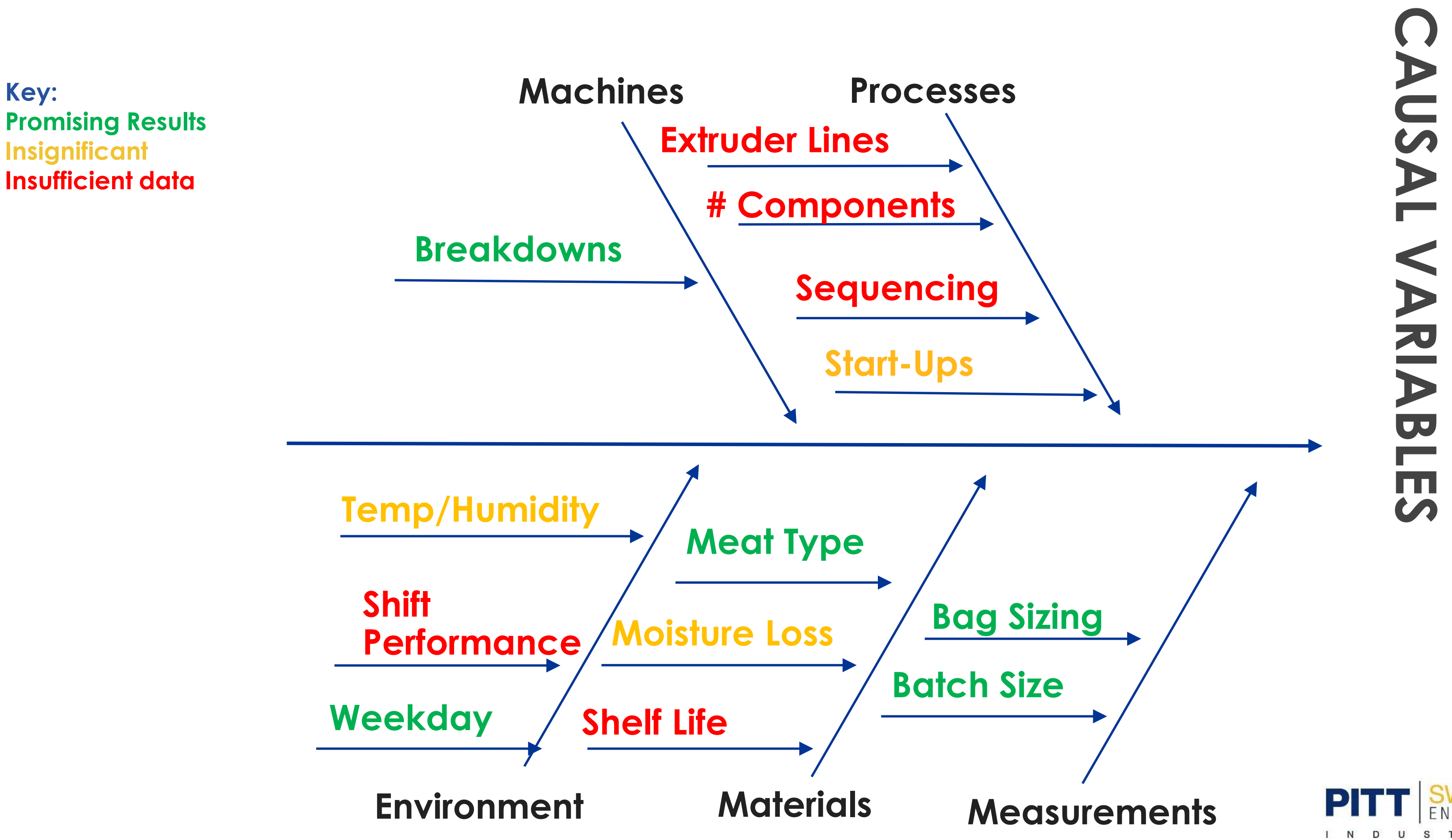
CONSTRAINTS



CONSTRAINTS

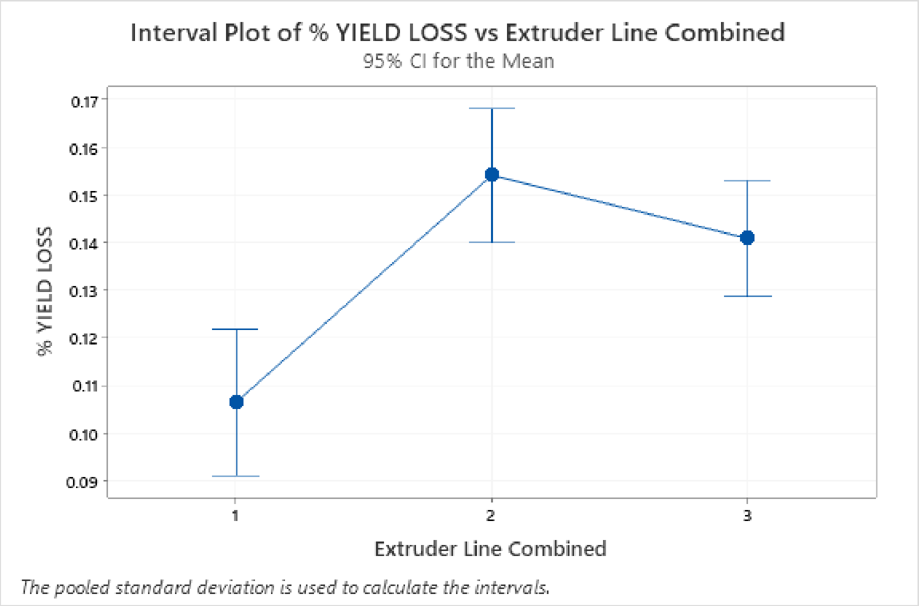


ANALYSIS AND RESULTS



Key:
Promising Results
Insignificant
Insufficient data
Machines
Processes
Extruder Lines
Components
Breakdowns
Sequencing
Start-Ups
CAUSAL VARIABLES
Temp/Humidity
Meat Type
Shift Performance
Moisture Loss
Bag Sizing
Batch Size
Weekday
Shelf Life
Environment
Materials
Measurements

EXTRUSION LINES



Extrusion Line	Number of Runs	Average Batch Size (Tons)	Shrink %
1	167	80.54	10.64%
2	202	81.03	15.41%
3	263	96.10	14.10%
Total	632	87.17	13.60%

Sample is only 1/3 of runs from March 2019 - April 2020, only mono-kibble formulas.

Extrusion Line 2 and 3 are significantly higher than Extrusion Line 1. However, due to inadequate data, no further conclusions can be drawn.

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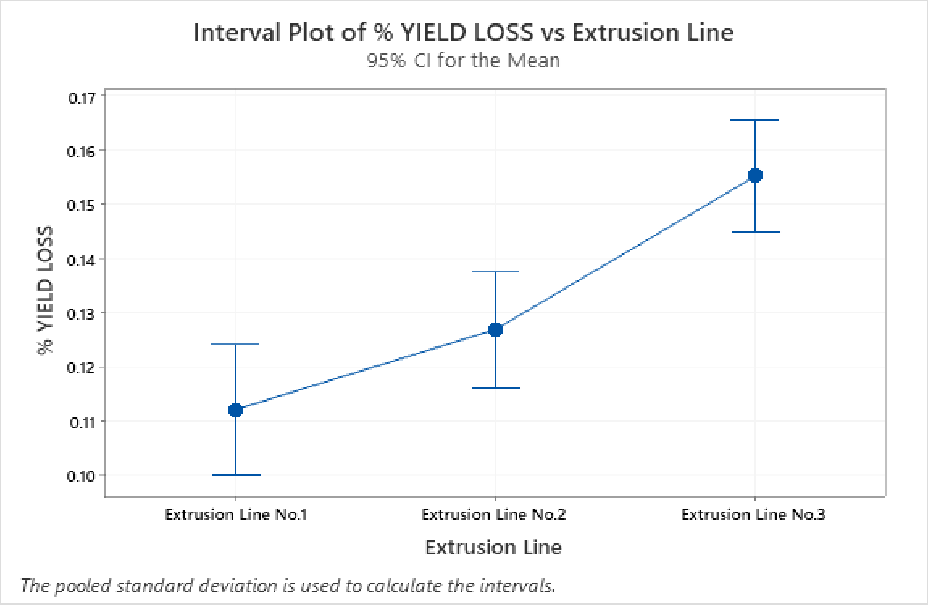
EXTRUSION LINES & BREAKDOWNS



Higher values in scrap lead to more shrink, as seen on Extrusion Line 3.

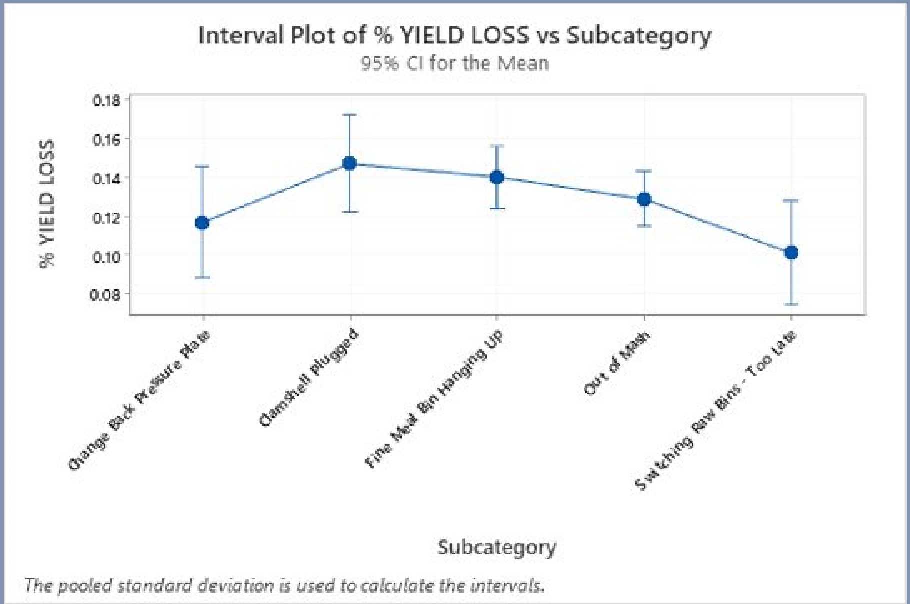
Extrusion Line	Number of Runs	Scrap (Tons)	Shrink %
1	167	67	11.21%
2	202	97.3	12.68%
3	263	138.5	15.51%
Total	632	302.8	13.34%

Grouping Information Using the Tukey Method and 95% Confidence

Extrusion Line	N	Mean	Grouping
Extrusion Line No.3	231	0.15506	A
Extrusion Line No.2	210	0.12682	B
Extrusion Line No.1	169	0.11208	B

Means that do not share a letter are significantly different.

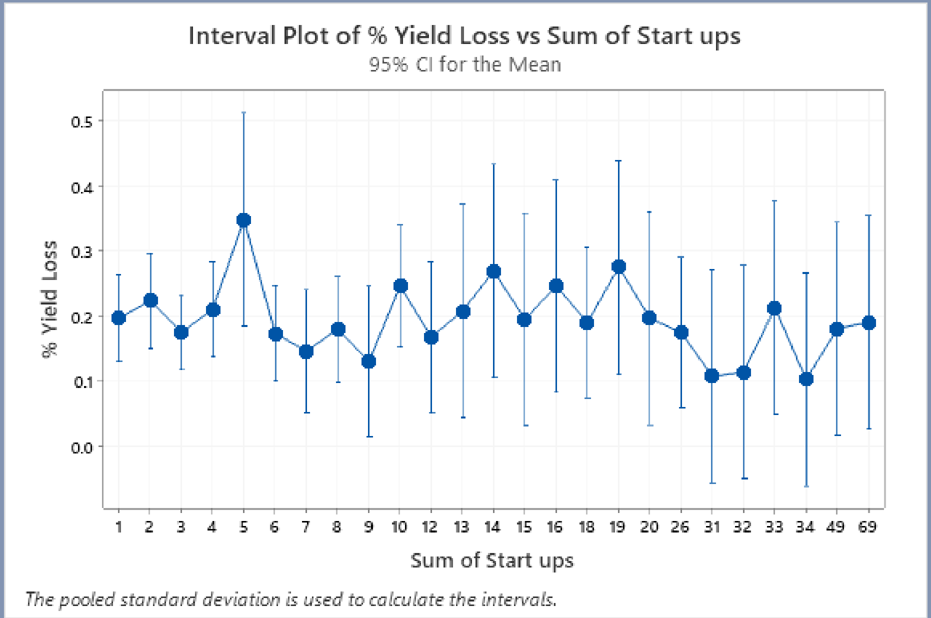
TOP 5 BREAKDOWNS



There is no statistical difference in the shrink caused by the 5 most common breakdowns

Breakdown	Occurences	Mean Shrink %
Change Back Pressure Plate	25	11.68%
Clamshell Plugged	33	14.68%
Fine Meal Bin Hanging Up	77	14.00%
Out of Mash	103	12.88%
Switching Raw Bins	29	10.12%

STARTUPS



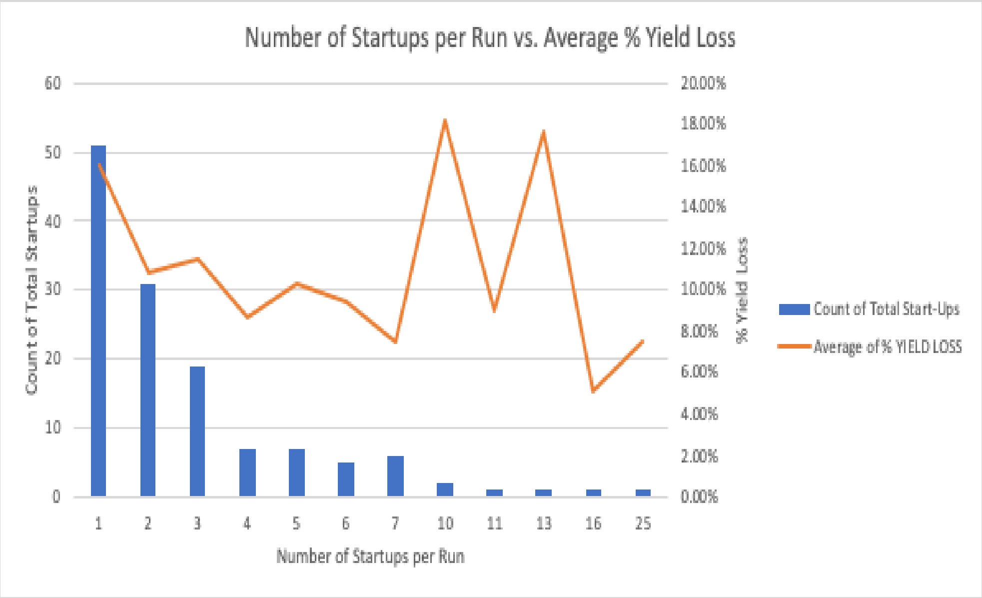
There is no statistical difference for number of startups and shrink.

There is room for improvement on startup data collection.

Data from the combined Shrink Database and Extrusion Moisture Tracking Database was used.

Only data for April-December 2019 could be used, and a large portion was missing.

STARTUPS

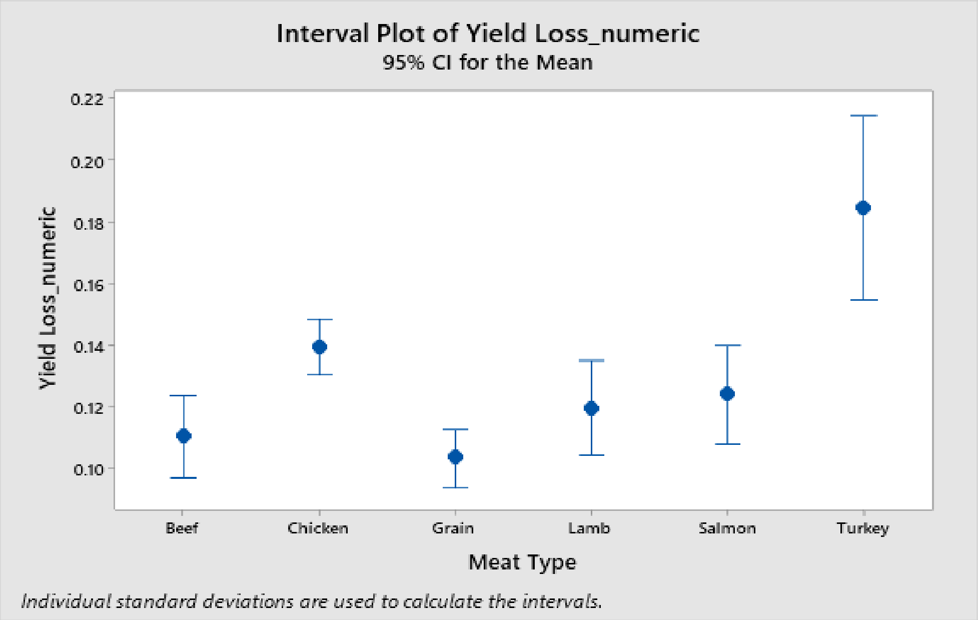


This startup data shows that as startups increase, shrink begins to decrease.

PPF provided additional startup data for January – March of 2020

There were discrepancies in the data, limiting the analysis accuracy.

MEAT TYPES



Meat Type	Occurences	Mean Shrink %
Beef	74	11.03%
Chicken	452	13.94%
Grain	190	10.34%
Lamb	78	11.96%
Salmon	148	12.39%
Turkey	91	18.44%

Turkey has a significantly higher shrink compared to other meat types.

Turkey is frequently produced in small batches – this brings attention to the influence on batch sizes.

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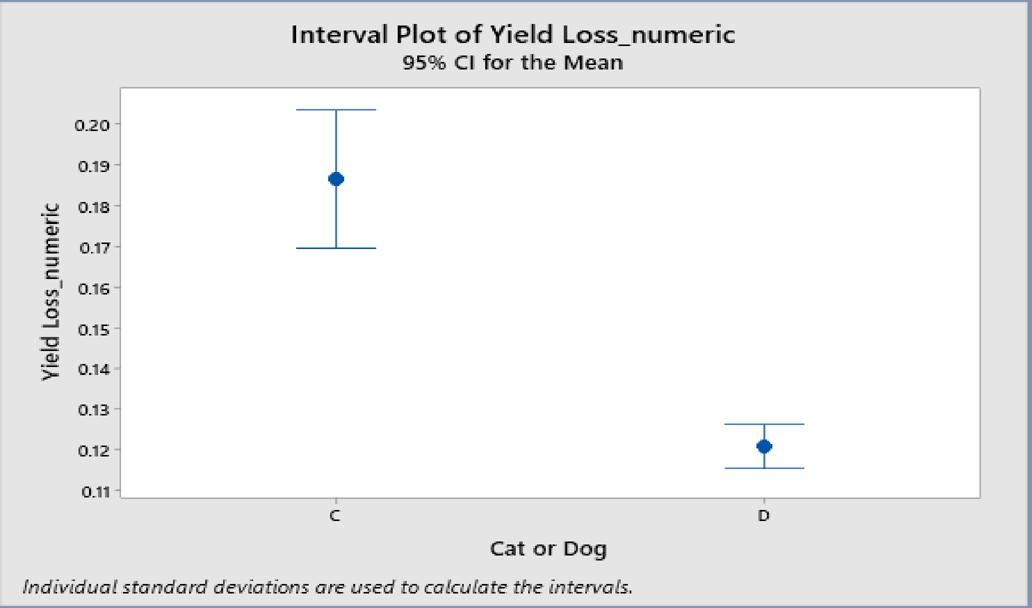
CAT AND DOG FOOD



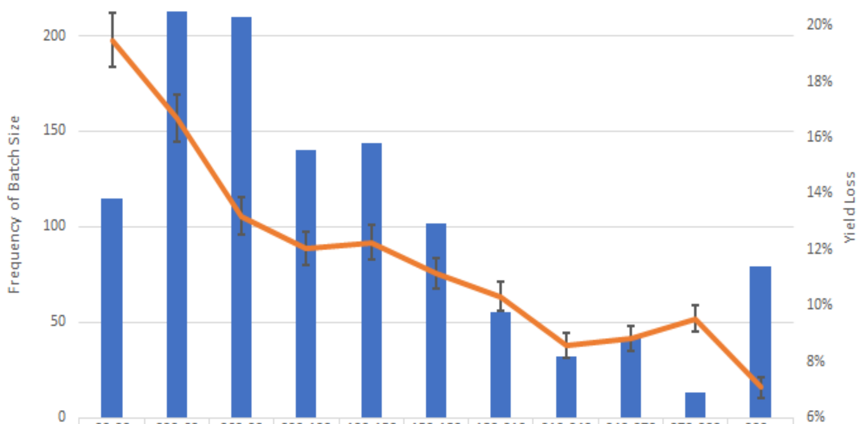
Food Type	Occurences	Mean Shrink %
Dog	980	12.10%
Cat	189	18.66%

Cat Food has a significantly higher shrink compared to Dog Food formulas.

Cat Food is typically run in small batches – again leading to believe batch size plays a role in shrink.

BATCH SIZING

Frequency of Batch Size and The Related Yield Loss



	00-30	030-60	060-90	090-120	120-150	150-180	180-210	210-240	240-270	270-300	300+
Count of BATCHED	115	213	210	140	144	102	55	32	42	13	79
Average of % YIELD LOSS	19%	17%	13%	12%	12%	11%	10%	9%	9%	10%	7%

Batch Size (Tons)

Data was binned with a width of 30 tons.

Any data >300 tons was accounted for in the overflow bin.

An analysis was performed for kibbles, slurrys, etc.

74% of the production runs are batched at less than 150 tons, and have an average shrink ranging from 12-19%

The analyses on dog kibble, cat kibble, and slurry yielded the same patterns and conclusions.

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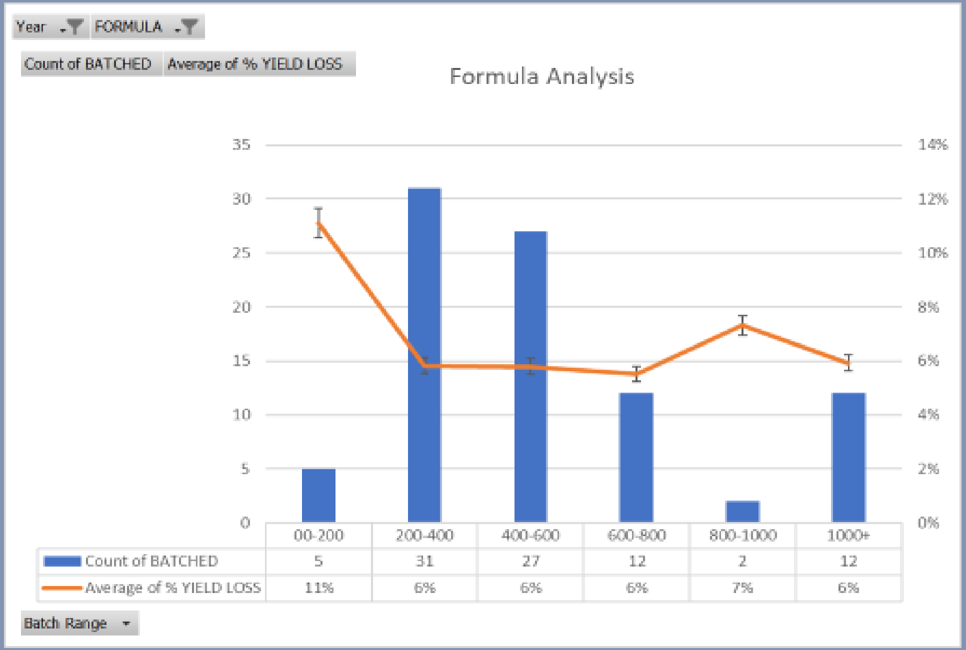
BATCH SIZING - FORMULAS



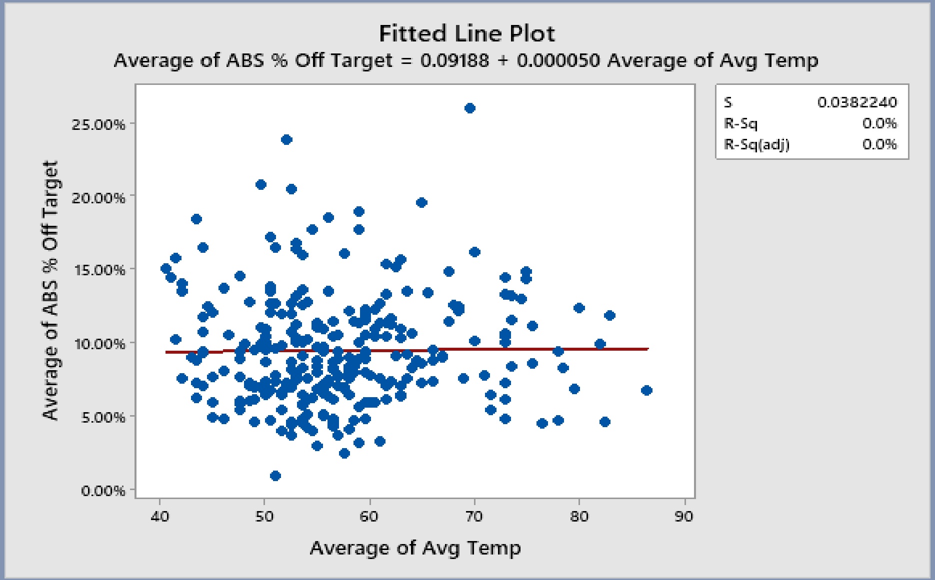
Formula WLDKN310 typically runs batch sizes 300-1000 tons.

Shrink again decreases as the batch size increases to 200+ tons.

Some formulas have different trends and batch sizing can be done on a formula specific basis.

An Excel based tool was built for the PPF Team to analyze Formulas on a case by case basis.

DAILY MEAN TEMPERATURE



No relation between temperature change and the shrink.

A similar analysis was completed for only days with a mean temperature >85 ° F, with repeated results.

PPF's Factory is not climate controlled.

Historic weather data was extracted from the NOAA website.

Data was combined with the Shrink Database.

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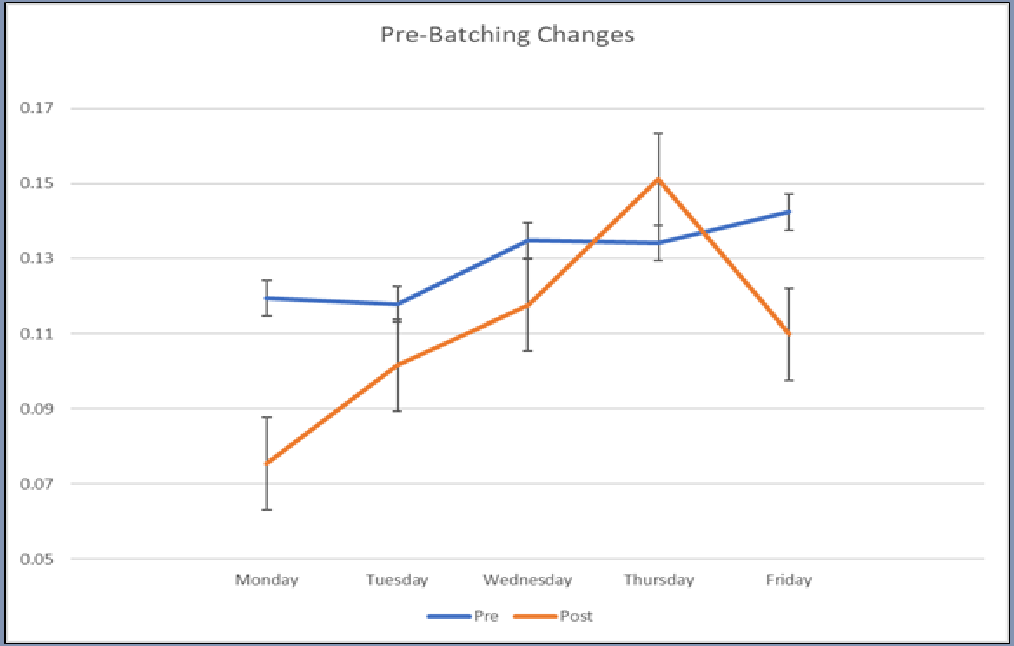
WEEKDAYS - SHRINK



PPF increased their efforts on pre-batching formulas beginning in 2020 Q2

Pre – 2019 & 2020 Q1
Post – 2020 Q2

Shrink is lower earlier in the week, possibly due to pre-batching.

The increased attention to pre-batching may have reduced bottlenecks and caused a reduction in shrink.

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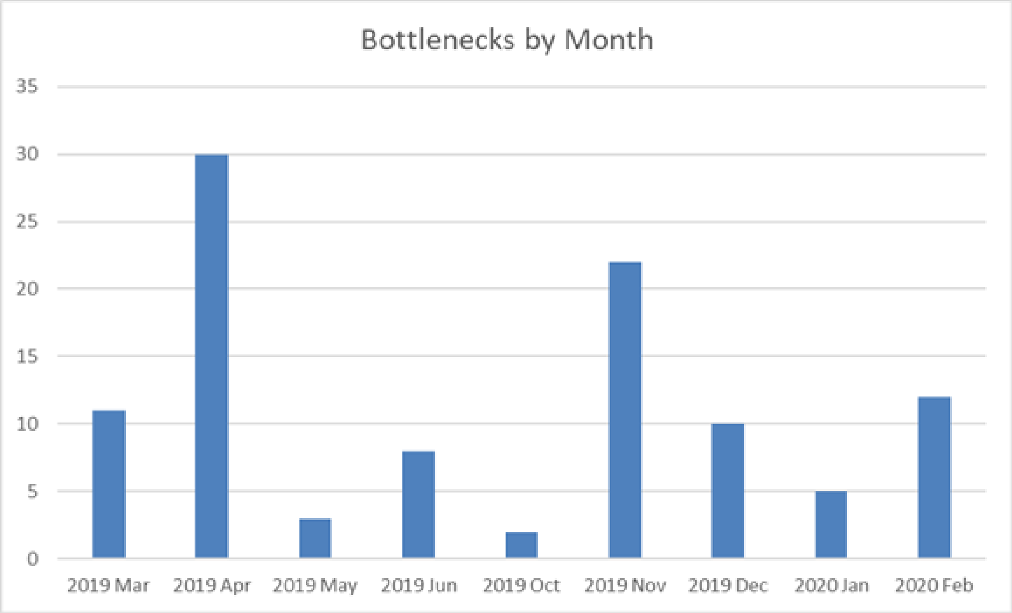
WEEKDAYS - BOTTLENECKS



Bottlenecks were analyzed to determine if pre-batching had a positive effect on the system.

This data is manually collected by the operational staff.

Bottleneck data appears to be very volatile between each month.

Performance is either truly this random, or data on bottlenecks is not recorded fully.

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BAG SIZING PROPORTION

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.1025	0.0161	6.36	0.000	
3	0.0413	0.0297	1.39	0.166	1.59
4	0.0242	0.0353	0.69	0.494	1.72
5	0.1473	0.0267	5.51	0.000	1.47
7	0.1490	0.0342	4.36	0.000	1.46
11	-0.0469	0.0591	-0.79	0.428	1.41
12	0.022	0.125	0.18	0.860	1.28
14	-0.245	0.469	-0.52	0.602	1.11
15	0.0184	0.0237	0.78	0.439	1.61
20	-0.217	0.142	-1.52	0.129	1.03
23	-0.391	0.943	-0.41	0.679	1.20
24	0.0255	0.0307	0.83	0.408	1.74
28	-0.0137	0.0220	-0.62	0.535	2.18
30	0.0701	0.0193	3.63	0.000	2.49
40	-0.0511	0.0373	-1.37	0.172	1.20
50	-0.0141	0.0223	-0.63	0.527	1.90

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.12028	0.00538	22.35	0.000	
Small	0.07565	0.00982	7.71	0.000	1.04
Medium	0.0104	0.0124	0.84	0.402	1.04

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.1307	0.0104	12.58	0.000	
Large	-0.0104	0.0124	-0.84	0.402	2.19
Small	0.0652	0.0142	4.58	0.000	2.19

A higher proportion of small bags produced leads to a higher shrink.

Using the estimated tonnage of product made leads to an inflation in shrink.

PPF does not weigh each bag produced, and assumes the bag fill weight is correct.

This bag fill weight is used to create an estimate of product produced – which is used to calculate shrink.

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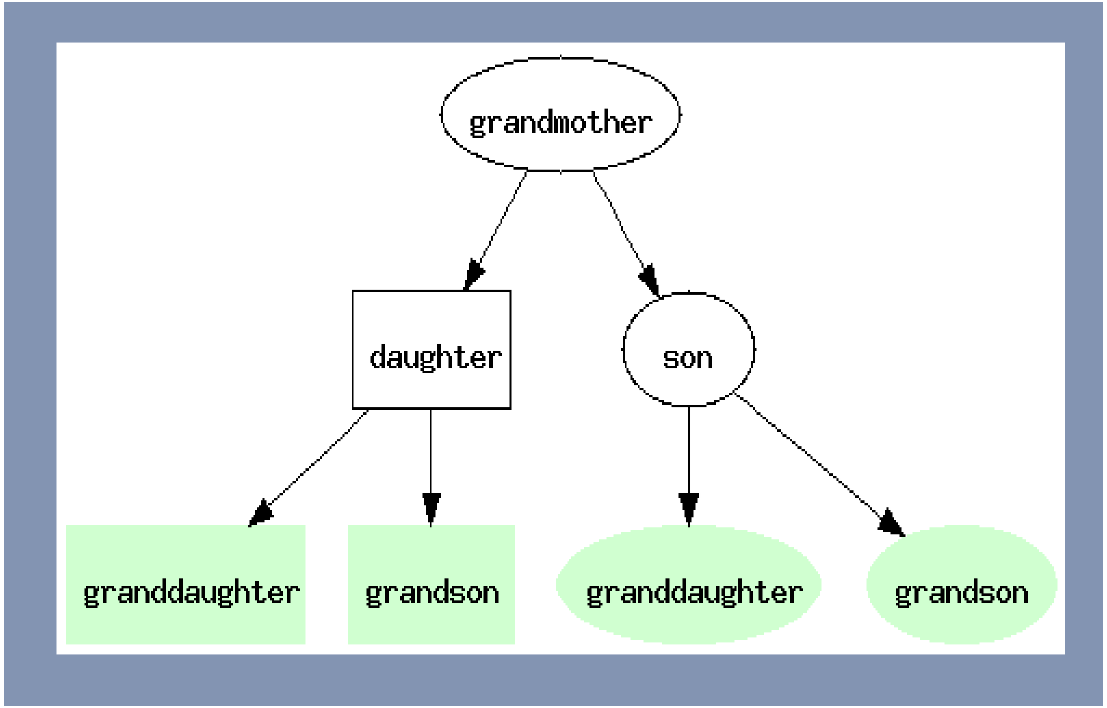
Recommendations, Implementations & Benefits

Data Collection Recommendations

Overall Recommendation: Introduce a Hierarchical format for data collection



Recommendation 1: Lot #/Run ID Implementation

Recommendation:
Incorporate a unique identifier in each of PPF's datasets

Implementation:
Include a column in each of the datasets for Run ID
Ex: 2004-28
Year Month Run #

Benefit:
Would allow for all datasets to be combined and for multivariate analysis to be conducted

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Recommendation 2: Recording Shrink and Extrusion Line for each Run

<u>Recommendation:</u>
Develop a means to look at the shrink and extrusion line for all runs including multi-kibbles

<u>Implementation:</u>
Include the extrusion line and shrink for all runs in the shrink database

<u>Benefit:</u>
Ability to analyze formula sequencing and multi vs. mono kibble formulas

Recommendation 3: Record Shrink by Shift

<u>Recommendation:</u>
Create a way to analyze the performance of different shifts relative to shrink

<u>Implementation:</u>
Include a shrink by shift in the Extrusion Moisture Tracking database

<u>Benefit:</u>
Performance indicator for the different shifts

Recommendation 4: Track the start and end time for each run

Recommendation:
Provide more detail in regards to start time, end time, and when a run breaks down in the shrink database

Implementation
Record the specific time for every start and stop of the extrusion process

Benefit:
Allows for a deeper analysis on how breakdowns effect shrink

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Recommendations, Implementations & Benefits

Process Recommendations

Recommendation 5: Reevaluate Batch Sizing

<u>Recommendation:</u>
Run formulas at an optimal batch size that would yield the smallest amount of shrink

<u>Implementation</u>
Use the Pitt IE team's Excel tool to view historical batch sizing per formula and use this information to help decide the size of a batch

<u>Benefit:</u>
The PPF team would be reducing the amount of shrink for each formula run

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Recommendation 6A: Re-analyze Bag Size Proportions and Weighing Techniques

<u>Recommendation:</u>
Weigh finished materials before bagging, or sample filled bags.

<u>Implementation:</u>
Record actual amount of material produced.

<u>Benefit:</u>
Understand variance in runs and calculate correct shrink.

Recommendation 6B: Re-analyze Bag Size Proportions and Weighing Techniques

<u>Recommendation:</u>
Perform a cost benefit analysis to determine what proportion of bag sizes to produce.

<u>Implementation:</u>
Determine the balance between optimizing the shrink and managing inventory/demand.

<u>Benefit:</u>
Reduce costs associated with both inventory carrying costs and shrink.

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Recommendation 7: Re-evaluate Extrusion Line Three

Recommendation:
Observe extrusion line three closely in the future to determine why it has a higher shrink than the other two extrusion lines

Implementation
Begin recording the extrusion line number and shrink for every run across all extruders so that more analysis can be done

Benefit:
More in-depth analysis on extrusion line three could be performed and its shrink lessened

THANK YOU

Perfection Pet Foods
Dr. Sherwin
Pitt IE Faculty

QUESTIONS?

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