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Project Number:
FN STF1

Material Waste and Changeover Efficiency At Stonyfield Farm

A Major Qualifying Project Report

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

By

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Irene Tsai

In cooperation with
Stonyfield Farm

Dated: April 26, 2007

Approved:

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Francis Noonan

ABSTRACT

This report, prepared for Stonyfield Farm, was focused on identifying work process standards for the reduction of fruit and flavor usage on the 6 oz yogurt cup assembly lines during the fruit and flavor changeover process. A series of interviews, observations, literary research and analysis, led to the identification of a standard quantity of allowable usage to be generated from the fruit changeover process. Additionally, analysis on the feasibility of upgrading the current fruit dosing system was performed.

EXECUTIVE SUMMARY

This report, prepared for Stonyfield Farm, was focused on identifying methods for the reduction of fruit and flavor usage on the 6 oz yogurt cup assembly lines during the fruit and flavor changeover process. A series of interviews, observations, literary research and analysis, led to the identification of a standard quantity of allowable usage to be generated from the fruit changeover process at thirty pounds.

In comparing two methods of performing fruit changeovers on the line, a fruit to fruit push versus a water push, it was determined that the fruit push was the most cost efficient method. While the water push method took five minutes less to perform than the fruit push, the value of time the five minutes lost was calculated to be $260.91. The fruit to fruit push method used an additional twenty five pounds of fruit at the cost of $34.50.

Additionally, analysis on the feasibility of upgrading the current fruit dosing system was performed. An investment of approximately $126,000 would see a payback within a little more than two months. By upgrading the current fruit dosing system, operators will no longer need to spend as much time concentrating on adjusting the fruit valves to better control the range of fruit distributed into each cup.

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1. INTRODUCTION

Stonyfield Farm is a manufacturer of dairy-based goods, such as smoothies, ice creams, and yogurt. It's headquarter site, located in Londonderry, New Hampshire produces smoothies and yogurt, the latter being its main product. Stonyfield Farm competes not only with its domestic sister production sites, but those internationally as well, which operate under the name Dannon Yogurts of Group Danone based in France. Stonyfield's main concern is to comply with FDA guidelines to produce saleable and quality goods, but at the same time trying to keep the manufacturing costs at a minimum.

Stonyfield differs in its fellow production sites in that 80% of the raw materials used for the manufacturing process are organic, which cost at least three times as much as conventional material. The cost per product to produce Stonyfield's organic yogurt is greater than what similar yogurt manufacturers face with their use of conventional ingredients. As a result of the high costs for its raw materials, Stonyfield is interested in determining methods to reduce its production costs (Petrak, 2006).

As an environmentally-friendly corporation, Stonyfield is interested in reducing the amount of material waste, specifically fruit and flavor waste, innate in its process of manufacturing the product. Additionally, Stonyfield's growth in sales increased by 31.2%, the highest of all yogurt manufacturing brands with the closest brand coming in at 9.6% of growth. Due to this growth, the volume in material waste also increases (Petrak, 2006).

First, background research on the FDA guidelines for proper manufacturing processes and Stonyfield's own product requirements will be gathered to compare and determine the overall goal of both organizations and how they fit together. The method of changing SKUs will be specifically targeted, as there is a need to perform this procedure both quickly but also with minimal amount of waste. Additionally, there is a lack of a well defined standard on how this procedure is to be properly performed.

Observations of the changeover process on the lines will be observed and recorded. The baseline quantity of milk and fruit usage will be established in order to determine the quantity of waste which must be generated to properly maintain the quality of the product. From there, interviews with the filler operators on how changeover procedures were performed and their suggestions for areas of improvement were gathered. The ideas were then be modeled and evaluated to determine the most feasible, time and cost-efficient solution, and a well-defined changeover standard will be created.

Ultimately, by optimizing the changeover process through modifying the current practice will result in greater efficiently and the use of fewer resources. This will be possible through the development and establishment of a well-defined changeover procedure based upon the data gathered, Stonyfield will see a reduction in waste generated in the process in an efficient manner.

2. BACKGROUND

It is important to identify the intricate processes required in yogurt manufacturing, to better understand the fundamental requirements for making a quality cup of yogurt. This will provide the foundation in understanding the needs of Stonyfield Farm as a manufacturer of yogurt, combined with its mission as a brand, along with the requirements of the FDA in producing a quality food product.

2.1 History of Yogurt

Yogurt is a gelatinous-like substance, generated from the fermentation of milk. The history of yogurt as a food item dates back to the 11th century, as its origins were accidental when bacteria in milk began to ferment, producing its dense liquid-consistency. A Russian biologist, Ilya Mechnikov, believed that a diet heavy in the consumption of yogurt resulted in the long lifespan of Bulgarian peasants. Mechnikov believed Lactobacillus, a lactic acid bacterium, was essential for good health and made it his work to popularize yogurt throughout Europe (Flora, 2002).

The popularization of yogurt blossomed with Isaac Carasso, who in 1919 started a yogurt plant in Barcelona, Spain. This yogurt plant, named Danone, better known in the United States as Dannon, industrialized the production of yogurt. Yogurt is a popular food of "South Asia, Central Asia, Western Asia, South Eastern Europe and Central Europe", enjoyed alone as a snack item or used in entrees. In the 1940s, Danone introduced yogurt with fruit jam at the bottom to slow the process of the yogurt decaying. Even with its extensive history of existence, it was not until the late 1980's health craze when yogurt gained acceptance as a food product in the United States (Flora, 2002).

2.2 Stonyfield Farm

Stonyfield Farm is the premiere manufacturer of organic dairy products in the United States, the bulk of which is yogurt-based goods. Stonyfield differs from its competitors in the market by using ingredients which are all organic and natural- no artificial flavors, coloring, sweeteners, nor preservatives. The organic ingredients are purchased through vendors who do not employ the use of synthetic growth hormones and pesticides. Stonyfield Farm is currently the largest manufacturer of yogurt goods, and ranks as the third largest overall yogurt brand name (Petrak, 2006).

In the early 1980s, an organic farming school with the mission of maintaining agricultural practices began selling its homemade yogurt recipe under the name Stonyfield Farm to maintain funding for its school. The yogurt was made in small batches in an ordinary kitchen, and initially sold to just neighbors and local supermarkets in New Hampshire. However, by the mid 80's with the ever increasing demand for its product, its founders realized they had laid the foundations for an even greater plan- they no longer needed a school to teach and maintain the history of agricultural practices, instead, producing their yogurt alone would do just that.

In 1988, Stonyfield Farm relocated to Londonderry, New Hampshire and yogurt making became an industrialized process, replacing handmade batches with yogurt dispensing machines. By the 90's, the natural and organic health craze boomed and demand for Stonyfield's Stonyfield's entire organic yogurt product grew (Hirschberg, 1993). Consumers were suddenly interested in all natural and all organic products, ones without bovine growth hormones in the milk, artificial sugar, and other man-made additives. The Londonderry plant produces hard yogurt products in cup form with flavoring and/or fruit pieces, in addition to a liquid flavored yogurt smoothie drink.

In tune with its original company mission, Stonyfield is a company committed to not only producing healthy food products, but having a positive impact on the environment (Hirschberg, 1993). At least 10% of the company's profits go towards protecting or restoring the Earth. Current environmental business practices, such as recycling and reusing boxes, have supported Stonyfield's interest in protecting the environment.

2.3 Federal Drug Administration (FDA)

The United States food manufacturing industry is regulated by the Food and Drug Administration (FDA). Explicit quality standards are set by the United States government's FDA, which derives its authority and jurisdiction from acts of Congress. The FDA is responsible for regulating "food, dietary supplements, drugs, cosmetics, medical devices, radiation emitting devices, biologics, and blood products" (Coleman, 2002) in the United States. Food manufacturing sites must comply with FDA standards in order to produce quality, saleable goods.

One Act which regulates the net quantity of product placed per package may be found in the Fair Packaging and Labeling Act of 1966, which required that all consumer products now carry a label. This label was required to state:

- The identify of the product
- The name and place business of the manufacturer
- The net quantity of contents (Coleman, 2002))

2.4 Yogurt Manufacturing

The industrialized process of making yogurt product occurs in five main stages- receiving, pasteurization, production, incubation, and storage. In the first stage of receiving, raw materials arrive and are stored until ready to be processed. Dairy products may be stored up to a period of four days without going through the pasteurization process. Raw materials such as powders may be stored indefinitely and are sampled by the Quality Department prior to their usage in processing (Stonyfield Farm: SOP for Quality Control, 2006).

In the second stage, the raw materials are processed. Dairy products go through the pasteurization process to eliminate harmful bacteria and increase the shelf life of the product. The product is then blended with powders and other additives to bring it to the specifications for Stonyfield Farm's yogurt product, known as the base (Stonyfield Farm: L. Reuteri Bulk Culture, 2004).

At the production stage, the base is packaged on the assembly lines with over eighty different fruit and flavor fillings. Figure 2.1 illustrates the three types of fruit and flavoring types used by Stonyfield for their yogurt product.

Fruit and Flavor Filling Types

	Fruit	**Flavor Syrup**	**Liquid Flavor**
Description	Fruit pieces	Flavor syrup	Liquid flavoring
Product Type	Bottom of cup	Bottom of cup	Blend w/base
Examples	Strawberry (diced.) Blueberry (whole pieces)	Chocolate, Caramel	Vanilla, Key Lime

Table 2.1 Stonyfield Farm's main fruit and flavor filling Types

Fruit pieces sit at the bottom of each cup, and may either come as whole or diced pieces. Flavor syrups, such as chocolate and caramel, also sit at the bottom of each cup, and liquid flavors which are blended with the base prior to being dispensed into cups.

From there, each cup is sealed, boxed into cases (each case holds twelve cups), then conveyed to the incubation room. At the final stage, the base sits in the incubator until the base ferments into its yogurt form. When this occurs, the yogurt is moved through the chill tunnel to cool down to 50 degrees (Stonyfield Farm: HACCP, 2004) until it is finally stored in the shipping room ready to go out the door.

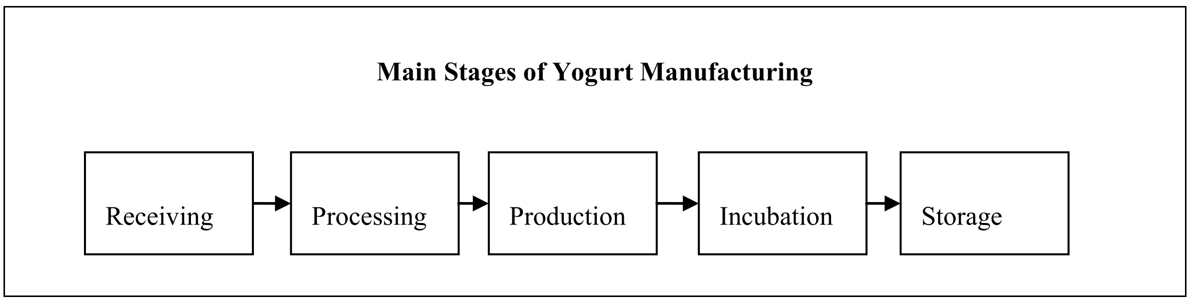

Figure 2.2 – Yogurt Manufacturing Stages

Throughout each stage, the temperature of the product must be maintained to ensure proper fermentation of the milk to create hard yogurt product. Quality checks are performed countless number of times through each stage to ensure these specifications are being met throughout the whole process.

3. METHODOLOGY

A number of varying methods will be used to gather information on how the current changeover process takes place, and how to optimize this process by reducing waste and time. The objectives in order to complete the goal of identifying best practices are as follows:

- Understand the business (organization, process, products)
- Identify the main areas generating waste through the manufacturing process, specifically in production.
- Discover the practice differences amongst the filler operators during the changeover process.
- Achieve an in-depth knowledge of the practices through evaluation
- Determine the most optimal changeover process

The first objective is to understand the business of yogurt manufacturing. This was achieved through background research of how yogurt is manufactured along with information on Stonyfield itself as a company; its mission statement and the types of products manufactured onsite.

Following this, line observations were made to see how different filler operators performed the changeover process. Differences amongst each operator's method were being noted. Additionally, interviews with the operators were being conducted in which the operators explained how the changeover procedure is performed. Analysis of the data was be performed by modeling the different methods to determine the most optimal changeover process to save time and decrease waste material.

3.1 Background Research

FDA guidelines for proper manufacturing processes were gathered, specifically for product weights and handling of product. This information was compared with Stonyfield's own product requirements. The different factors- such as quality, cost, time, and efficiency- were then benchmarked. The two were compared to determine the overall goal of both organizations and how they fit together.

Additionally, data on the quantity of each SKU's average production and which of the manufacturing lines they run on were obtained to determine the top two flavors or fruits produced the most often. Also, data on which of the lines generate the most waste according to fruit or flavor type were obtained. Through background research, the top two SKUs and line(s) which produce the most waste were identified, which became the focus as changes these would generate the most impact.

The capabilities of each assembly line's output of cups per minute would also be acquired. This was be used to weigh the values of labor versus waste generated. Whether it is more important to Stonyfield to produce more product at the cost of generating more waste through changeovers, or decreasing the changeover waste at the cost of losing production time were compared.

3.2 Flow Chart

Stonyfield Farm's yogurt manufacturing process was modeled with a process flow diagram. This outlined the steps involved through the process of receiving the raw material until the last stage of producing a final product.

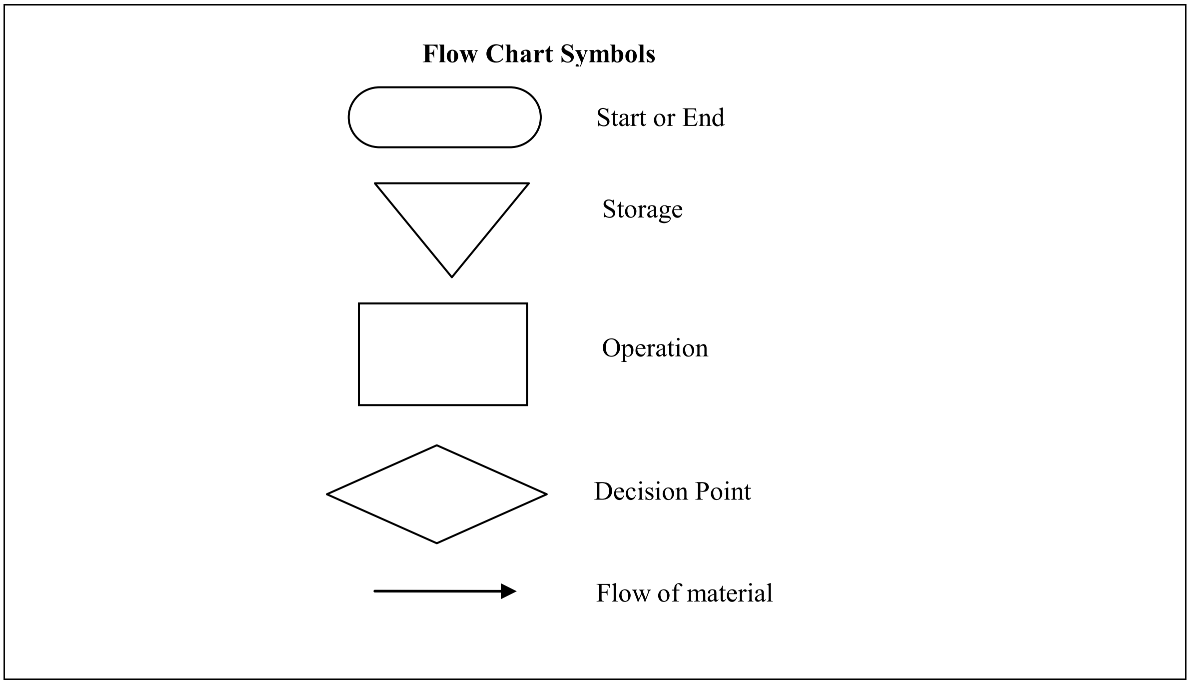

Figure 3.1 – Flow Chart Symbols

A flow chart aided in the analysis of a process through a series of diagrams which illustrated its basic elements, such as tasks, flows, and storage areas. An elongated oval indicated the start or end of a process, an inverted triangle indicates storage, a rectangle shows an operation, the diamond a point of question to make a decision, and an arrow indicates the direction of flow throughout the chart.

3.3 Fishbone Diagram- Identifying Areas of Waste

Throughout the entire manufacturing process, from the reception of raw materials to the final stage of having produced a finished product, waste is generated. The main focus of this project was to minimize the amount of waste generated during the production process, where the bulk of the waste is produced. A fishbone diagram, also known as a cause-and-effect diagram, is an analysis tool used to identify effects and the causes which contribute to those effects (Chase, 2004). A fishbone diagram was generated to identify the main areas and processes where waste is generated during production and causes as to why this occurs.

3.4 Line Observations

Observations of how the changeover process is performed by operators was done to gather data on how the procedure is done, and how differently each operator may do so. Observations of the changeover process was made on the line(s) determined to manufacture the top two SKUs which generate the most waste, as discovered from the background research. The steps involved for the changeover process will be outlined.

The amount of time it takes for the operator to perform the changeover and the amount of waste generated from each operator's process was recorded with a stopwatch. At the same time, the waste generated through the changeover process was captured in buckets to be measured. This was used to determine how much is generated from each step and how much waste is generated according to each operator's individual performance and method.

3.5 Interviews

Organized interviews with line operators, who are the key operators in controlling the usage of fruit on the lines, were be conducted to further gather information on how they each individually perform operations related to fruit usage. The interviews were compared with what each operator what actually observed to be performing out on the lines. Operators were asked why they perform each procedure the way they do and any suggestions they may have for improvements was also be noted. Also, information on how they were trained and why they perform certain operations in their specific manner was obtained.

Additional interviews with individuals outside of production was conducted to gain further understanding on what is practiced by line operators, as well as the practices of those in the quality department, which affects production.

3.6 Determining the Best Practice

The final objective of the project is to determine the most efficient practice in performing a changeover, minimizing both cost from excess waste and time loss for the operator to perform the procedure. This is possible through the gathering and analysis of the following:

- Background research on the yogurt manufacturing process, modeled with process flow diagrams
- Determining areas where fruit and flavor loss occurred, particularly through production, modeled with a fishbone diagram
- Obtaining data on the average production schedule, indicating the highest volume SKU and highest quantity of waste generated from each run (strawberry, blueberry, vanilla, chocolate)
- Obtaining data on the lines which produce the highest value of fruit waste
- Obtain data on the quantity of cups produced per minute by each line. Compare with how much waste that is generated cost. Measure the variables of time and waste according to cost for Stonyfield to determine which variable should be the most optimal to focus upon.
- Obtaining the Standard Operational Procedure for changeovers.
- Interviewing line operators on how changeovers were performed. There are four operators for each line (four operators each line).

- Observe the operators during the changeover process for the three specified fruits and flavors on the two specified lines. During the observation, have waste generated through process contained in buckets so they may be later used to weigh and measure. Also, outline the steps involved in the process. Finally, record the amount of time it takes to perform each step with a stopwatch.
- Compare the SOP to the interview and observed procedure performed on the line.
- Determine the most optimal procedure, according to which variable Stonyfield is more interested in controlling.

In developing the standard to minimize downtime and waste, both factors conflict with each other. The trade offs between whether the cost of time to perform a changeover was a more important variable than the cost spent on waste, or vice versa was be modeled.

Additionally, other areas of improvement to time and cost were noted according to observations made in correlation to changeovers on the lines.

4. RESULTS

The data gathered through the various research methods serve to provide the foundations of the changeover process. Background research was conducted to determine the product SKU which was schedule to produce the most volume. This data was compared along with the highest volume of fruit or flavor usage, and which fruit or flavor ran the most often on each assembly line.

A flow chart was created to outline the stages of the manufacturing process to provide an overall picture of how materials move from input of material to its output as a product. Mention Interviews/Observations/Etc.

4.1 Background Research

Background research on production schedules was obtained through gathering data from various sources through Stonyfield's production database. This information provides as a guide to the average scheduled production of each specific SKU per week.

In Table 4.1, the average scheduled production of each SKU per week is listed in descending order.

Scheduled Production per Week

SKU	Milk	Fruit/Flavor	STNY*	TJ*	Total */Wk
40	NF	French Vanilla	15517	1282	16799
44	NF	Blueberry	13302	1462	14764
57	NF	Chocolate	11850	1264	13114
41	NF	Strawberry	10626	1051	11677
4002	LF	Vanilla	9958	878	10836
42	NF	Peach	10099		10099
45	NF	Black Cherry	8216	1086	9302
4006	LF	Strawberry	8425	711	9136
43	NF	Raspberry	7595	1125	8720
4001	LF	Blueberry	7151		7151
66	NF	Key Lime	5036	814	5850
20	NF	Plain	4640	807	5447
49	NF	Lotsa Lemon	5145		5145
4005	LF	Raspberry	4196	706	4902
39	NF	Berry Bash	4207		4207
46	NF	Apricot	3061	1051	4112
464	WM	French Vanilla	3918		3918
65	NF	Black Cherry	3843		3843
4008	LF	Peach	3219		3219
461	WM	Blueberry	3212		3212
468	WM	Strawberry	3179		3179
4004	LF	Maple	2598		2598
4011	LF	Caramel	1524	610	2134
603	Soy	Strawberry	2000		2000
604	Soy	Blueberry	1959		1959
4003	LF	Mocha	1929		1929
4010	LF	Lusc. Lemon	1859		1859
67	NF	Strawberry	1811		1811
4000	LF	Plain	1771		1771
608	Soy	Vanilla	1611		1611
605	Soy	Raspberry	1488		1488
466	WM	Vanilla	1441		1441
606	Soy	Peach	1423		1423
78	Light	Strawberry	1005		1005
609	Soy	Chocolate	1002		1002
77	Light	Blueberry	975		975
79	Light	Black Cherry	949		949
80	Light	Peach	872		872

* Cases (12 cups/case)
STNY= Stonyfield
TJ= Trader Joes
NF= Non-Fat Milk
LF= Low-Fat Milk
WM= Whole Milk
Light = Non-Fat Light Milk
Soy = Soy Milk

Table 4.1 - Average Scheduled Production per Week

Table 4.1 lists the volume of production scheduled on average according to SKU. However, this does not take into account SKUs which share the same fruit type. Table 4.2 (see below) accounts for this by listing the highest volumes according to fruit or flavor ingredient, which provides a more focused guide as to which fruit or flavor product to specifically concentrate on, as higher volumes of production require more changeovers, resulting in potentially higher volumes of waste in addition to cost generated from the waste.

Highest Volume Fruit/Flavor

Flavor/Fruit	**Total */Wk**
8078 Organic Strawberry	16856
8474 Organic French Vanilla	16799
8076 Organic Blueberry	16326
40105 Chocolate	12679
Vanilla Elan	12277

* Cases (12 cups/case)

Table 4.2 - Top Five Highest Volume Fruit/Flavor per Week

The top highest dollar amount of fruit or flavor waste generated per line in 2006 is illustrated below in Figure 4.1. This is the amount of direct losses according to fruit or flavor type. As observed in the data collected from Table 4.1 and Table 4.2, specific fruit and flavors appear to be generating the most waste and as a result monetary losses.

- Organic French Vanilla 8474
- Organic Blueberry 8026
- Blueberry 8183
- Organic Strawberry 8078
- Chocolate 40105

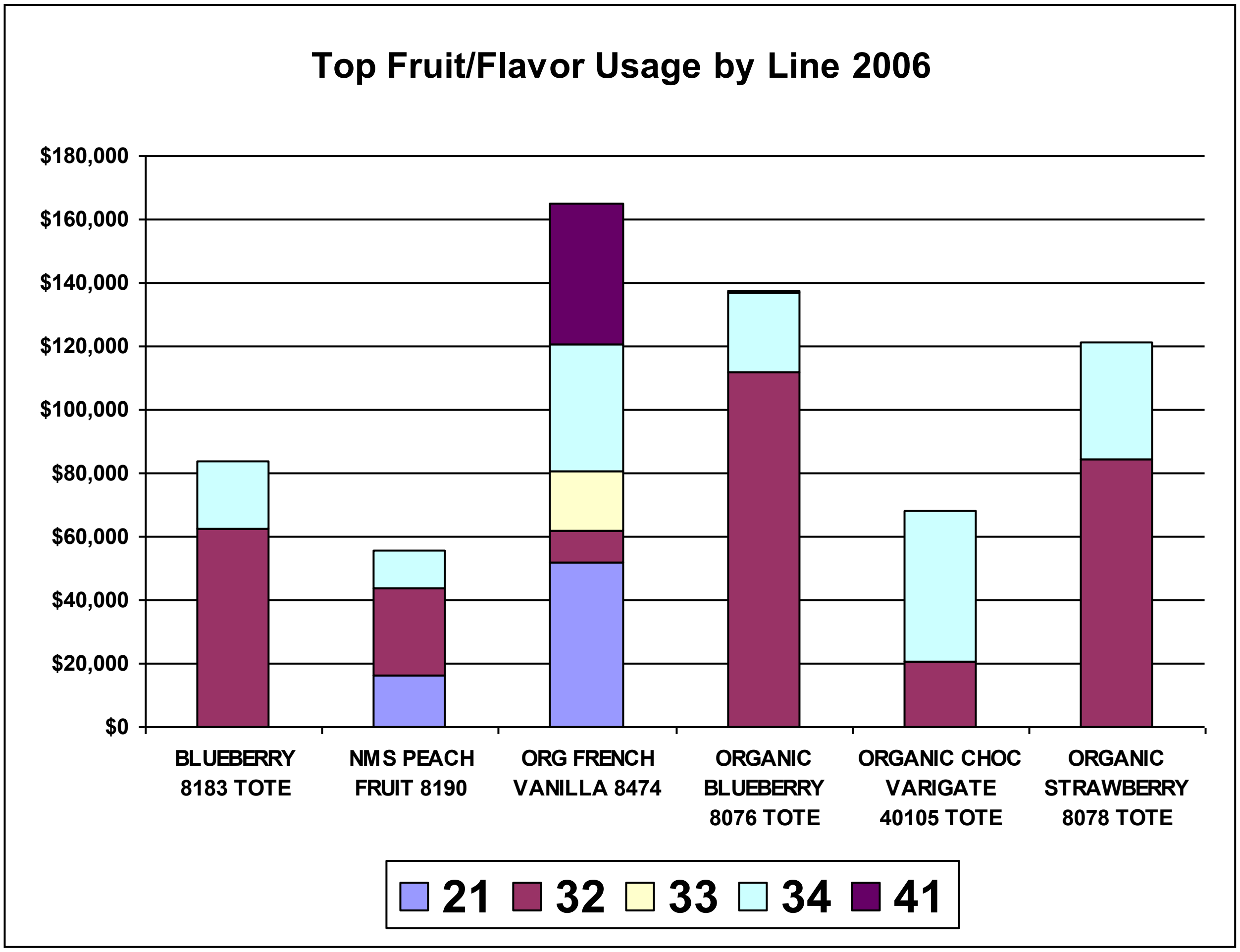

Figure 4.1 Top Five Highest Volume Fruit/Flavor Usage Losses by Line

Based upon the data collected, Line 32 and Line 34 will be specifically targeted in observing the changeover process for areas of improvement due to their high usages in 2006. Organic Chocolate 40105, Organic French Vanilla 8474, and Organic Blueberry 8076 will be the fruit and flavors to observe due to their high production volume and again, high recorded usages.

The selected flavors and fruit cover the three different types of product which the assembly lines must handle- the blueberry with a viscose jelly-like texture containing fruit pieces, the chocolate being a thick viscose liquid distributed to the bottom of each cup, and the French Vanilla as a pure fluid blended with the base before going into each cup. Organic Blueberry was selected over the conventional blueberry as the organic material comes at a cost of at least 50% more than the conventional. Strawberry will not be observed as generally all fruit products have the same consistency and do not vary as greatly as that of chocolate and vanilla's liquid flavoring.

4.2 Flow Chart

The flow chart is used to illustrate the steps involved in the manufacturing process, from the reception of the raw materials, through its processing methods, production, incubation, and storage until it is ready to be shipped out to consumers.

4.2.1 Receiving

Unpasteurized milk is received directly from dairy farmers and stored under a controlled temperature of a maximum 40 degrees (Stonyfield Farm, Cup Set) inside a designated silo for raw milk.

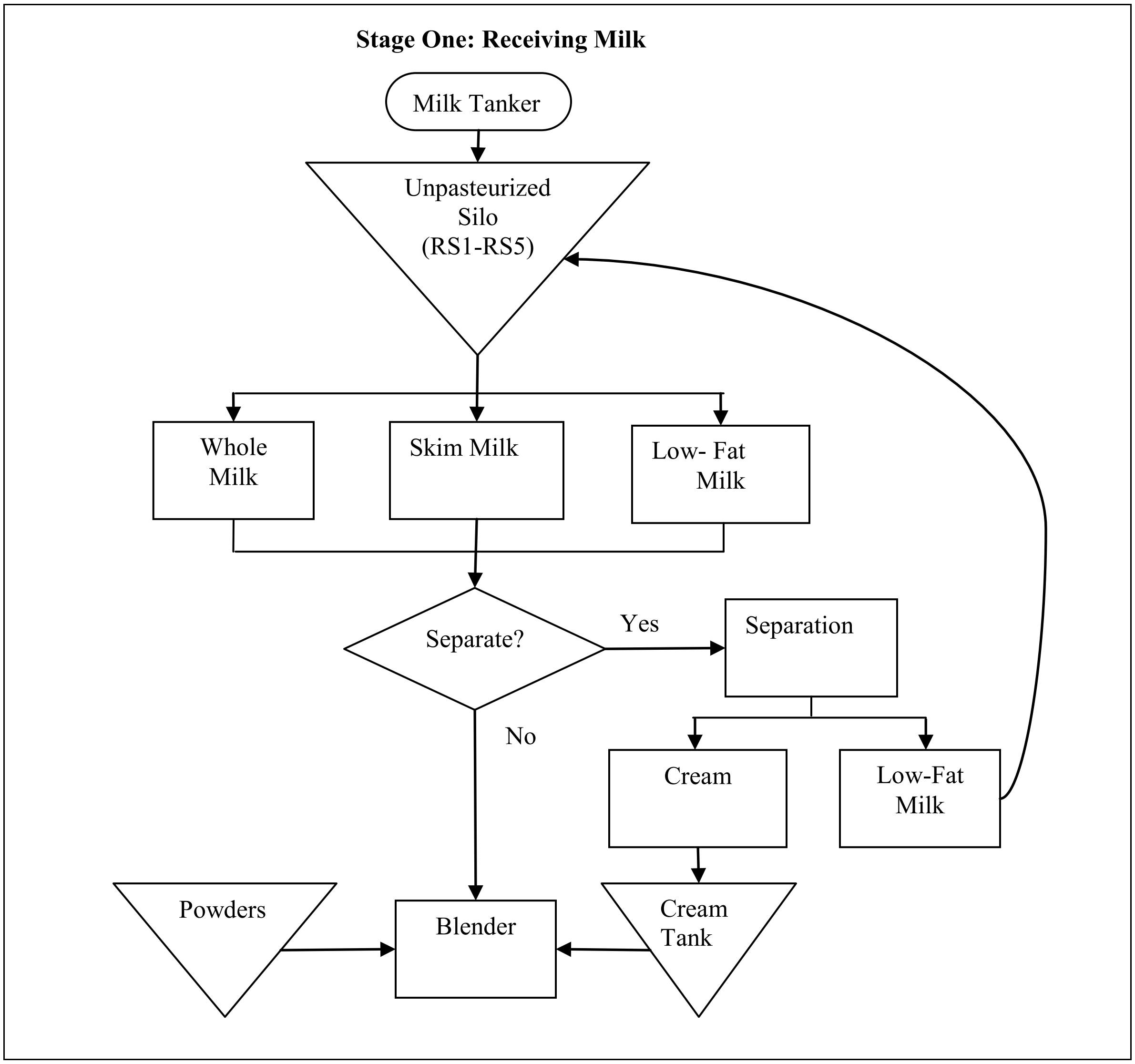

Figure 4.1 - Process Flow Chart: Receiving Milk

Both skim and whole milk are received, and are subject to separate treatments. With whole milk, the product may go through a separator to remove the butterfat from milk, reducing it down to low-fat milk. The butterfat is stored as cream, which can later be blended with skim milk, another method to make low-fat milk (Stonyfield Farm: Organic Milk, 2002).

4.2.2 Pasteurization

In the stage of powdering, unpasteurized milk is combined in a blender, agitating it with specific vitamins and other nutrients in powder form. Each yogurt product may have its own special formulation of milk and powders to create its specific base. The ingredients are blended, and then fed through to the High-Temperature-Short-Time (HTST) for pasteurization.

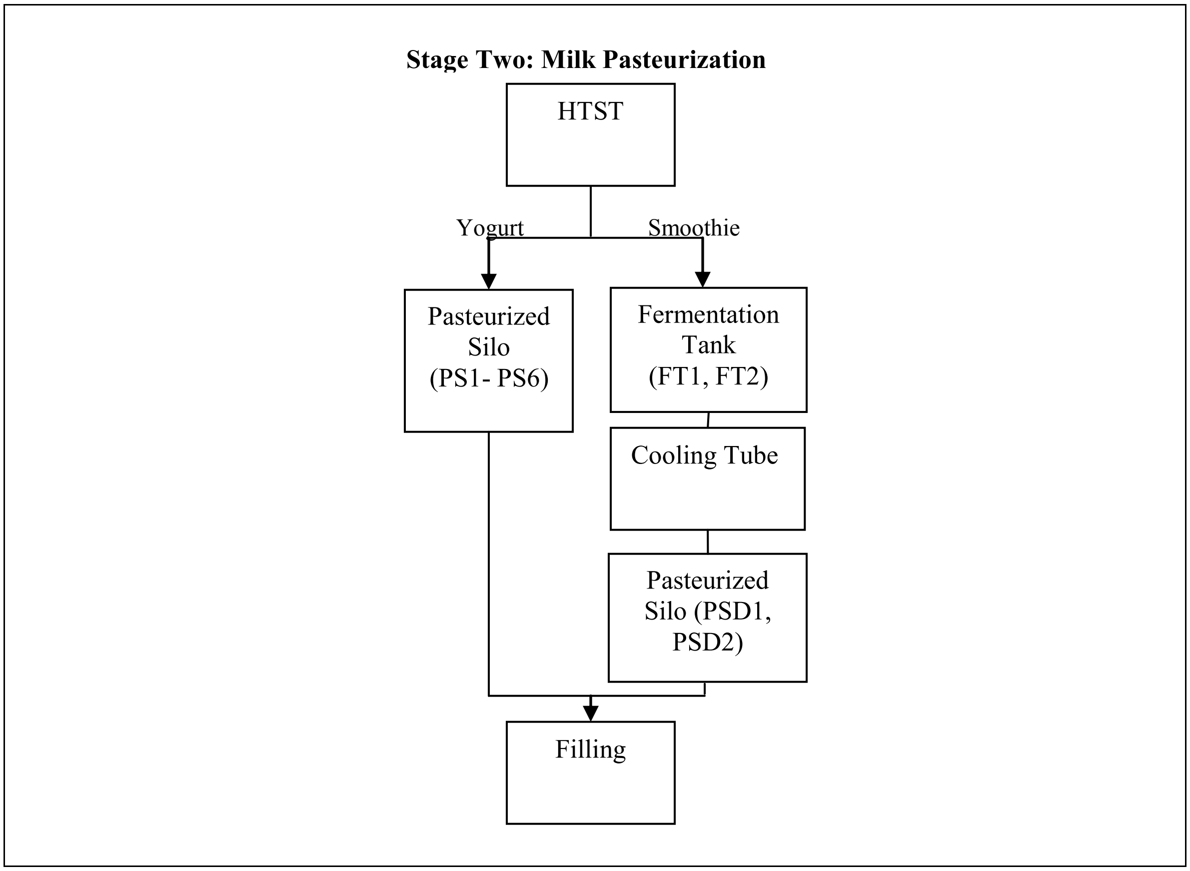

Figure 4.2 - Process Flow Chart: Milk Pasteurization

The process of pasteurization kills harmful organisms and increases the milk's shelf life. With the HTST process of pasteurization, the milk is heated for the same amount of time at a set temperature. The milk passes through metal plates and hot water, heating it to at least 161 degrees Fahrenheit for at least 15 seconds. For hard yogurt product, the milk is then subjected to a rapid cooling process and finally stored in a pasteurized silo. Once the base cycles through the HTST, it gets fed into a pasteurization silo for storage until it is ready for packaging (Stonyfield Farm: Yogurt Bulk DVS Cultures, 2004).

For yogurt smoothie product, as the base exits the HTST it is inoculated with cultures then stored in fermentation tanks. Once it is determined that the product has reached its specifications for the smoothie product, is it cooled through cold tubes then stored in pasteurized silos, ready for production.

4.2.3 Hard Yogurt Production

From each yogurt manufacturing line, an operator uses a screen to select the silo to connect his line to in order to receive base for the product. When a silo is selected, the base travels from the pasteurized silo to the filling room for packaging, through insulated piping. As soon as it is released from the silo, the base is heated to 108 degrees and cultures are inoculated into the mixture (Stonyfield: HAACP, 2004). The addition of cultures into the heated base starts the process of fermentation. When the base reaches the packaging room, it is held in a bowl located above of the yogurt assembly machine.

There are two operators assigned to the yogurt assembly machine, a filler and a packer operator. The filler operator works with the actual packaging of the yogurt into individual cups. The filler is responsible for making sure the yogurt based and fruit and packaged properly into each cup. Prior to startup, he must prepare stacks of cups in the Cup Drop, connect the hoses and totes necessary if he is making a product with fruit in the cup, and sure there are foil seals in place.

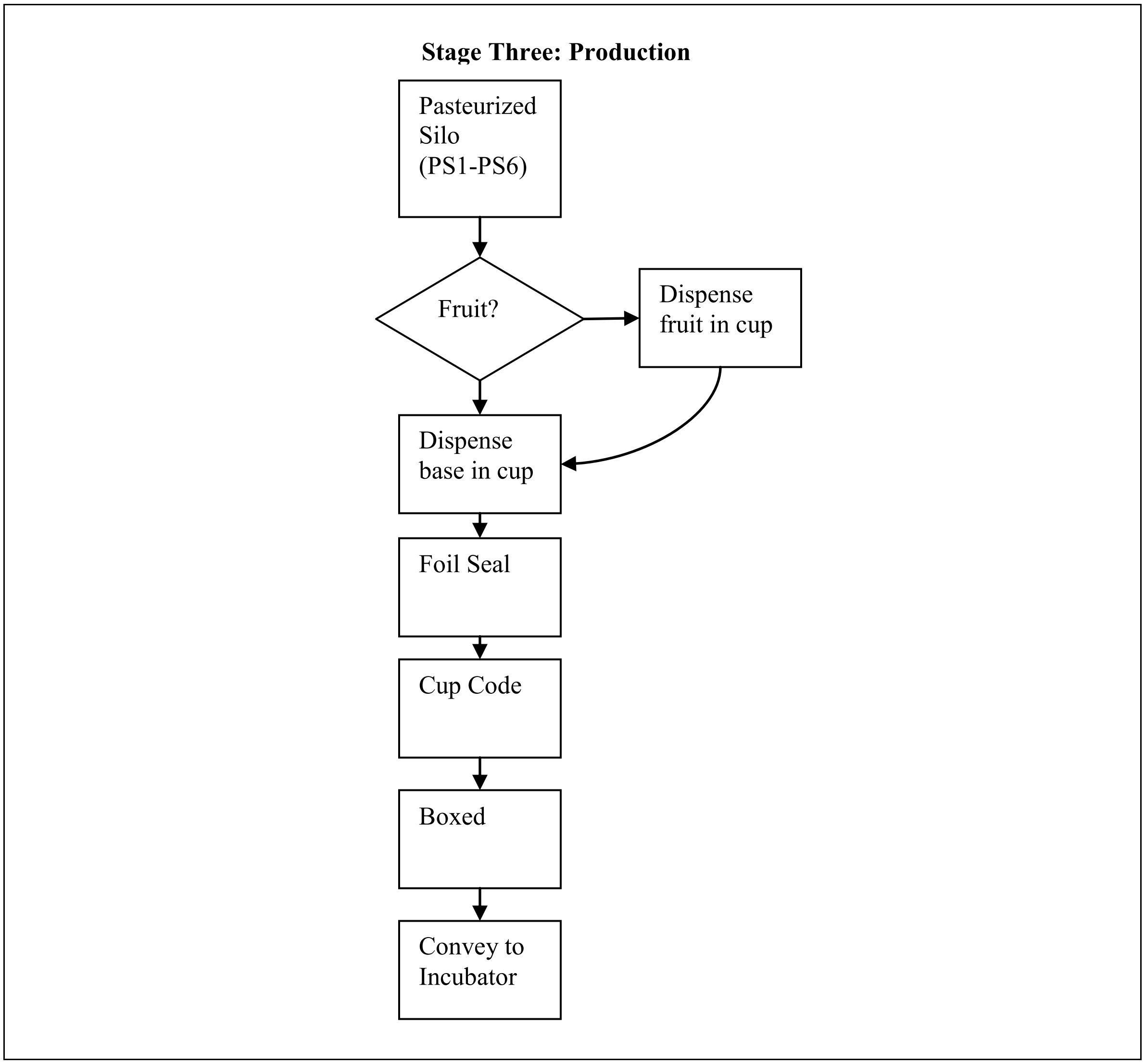

Figure 4.3 - Process Flow Chart: Production

During the production run, he must keep maintain the stack of cups in the Cup Drop, the number of foil seals in place, making sure fruit is being distributed in the cups, and lastly perform quality checks on the product every fifteen minutes. These quality checks, which occur every fifteen minutes, include checking the temperature of the product in the cup to make sure it is at the proper temperature range, taking a sample of cups to weigh on a scale to make sure they are within specifications, and making sure the foil seals the cup completely.

After the filler operator selects which pasteurized silo he is to pull milk from, he runs at least 120 gallons of milk out of the bowl and down the drain. This is the quantity of milk set by the quality department necessary to heat the milk, and ready to be filled in the cups. If the milk does not meet the minimum required temperature, the product will not ferment properly, resulting in a cup with hard yogurt but also a clear liquid consistency. As the yogurt assembly machine runs, yogurt cups are dropped into slots and carried by a belt, first filled with fruit at the bottom, topped off with the base, sealed, then conveyed to the packer operator (Stonyfield Farm: Organic Milk, 2002).

The packer operator works with the packaging of cups of yogurt into boxes into sets of pallets. He is responsible for making fifteen minute checks on the product for temperature, making sure the foil seals are in place, and ensuring each yogurt cup is properly coded with an expiration date. When the yogurt is conveyed to the packer operator from the filler, it goes down a conveyor belt and stamped with an expiration date prior it being boxed in sets of a dozen. These boxes are conveyed to a palletizer then these pallets are moved with a fork lift into the incubator.

4.2.4 Incubation

Pallets of yogurt are stored in the incubator. The incubator is a room maintained at a temperature greater than 104 degrees. Pallets sit in the incubator for at least three hours until an incubator technician checks the product (Stonyfield Farm: SOP for Quality Control, 2006). The incubator technician pulls cups of yogurt from each pallet at random to check the temperature and the consistency. He continues to check each pallet until they reach the appropriate specifications. Once this is reached, the pallet is moved with a forklift to the cooling tunnel for cooling of the product.

4.2.5 Cooling Tunnel and Storage

The cooling tunnel is the final stage of producing yogurt product. Each pallet slowly goes through a tunnel, which cools the temperature of the yogurt down to 50 degrees. Once the pallet reaches the end of the cooling tunnel, the yogurt is tested by a shipping technician to ensure it is of the proper consistency and temperature.

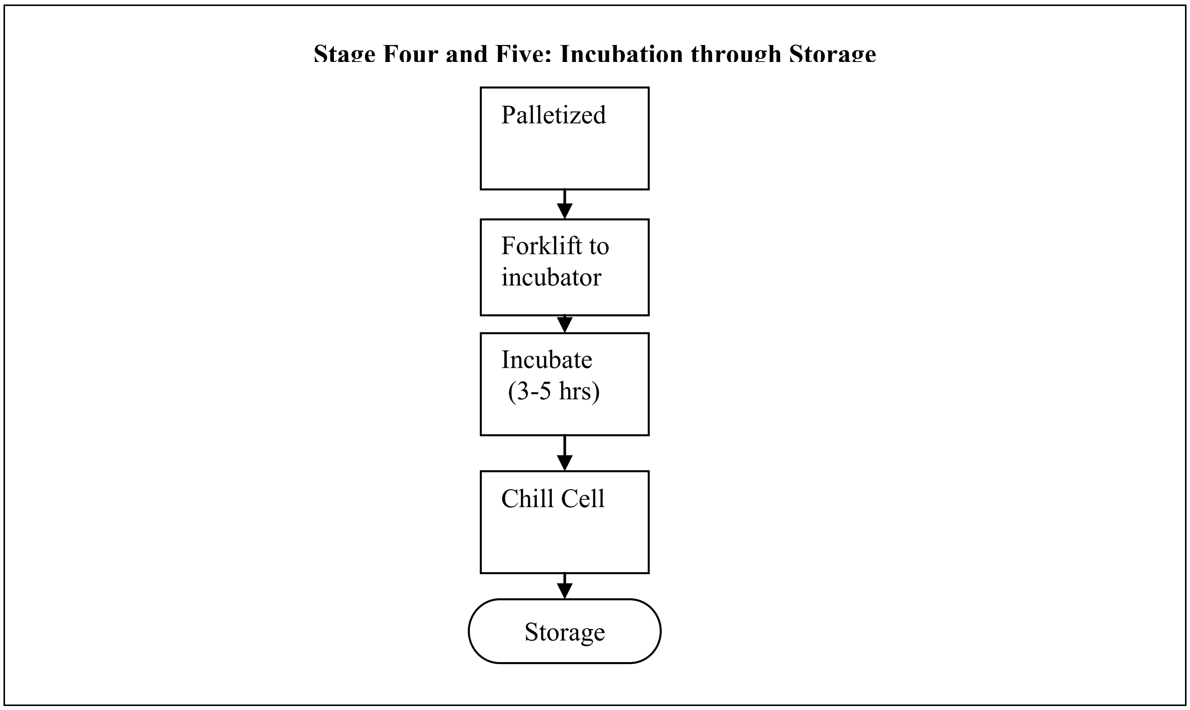

Figure 4.4 - Process Flow Chart: Incubation and Storage

The shipping technician pulls the pallet form the tunnel, and stores it in the shipping room which is regulated at 50 degrees (Stonyfield: HACCP, 2002). From here, the cups of yogurt are ready to be shipped and consumed. If a pallet does not meet quality specifications at any stage of the process, any operator or technician is allowed to place an orange “Hold” sticker on the pallet, then notify their supervisor to place the pallet on the Hold Board. The Hold Board is an Excel sheet accessible to all supervisors and managers to view and gauge how much of the product produced was placed on hold for quality issues.

4.3 Yogurt Waste Generated From the Manufacturing Process

As a manufacturer of food products, high quantities of waste are generated to maintain safe food standards. In the past few years, Stonyfield's output of product has tripled. In turn, the amount of waste generated from the manufacturing process has increased along with this increase in production. Throughout the process of manufacturing yogurt, waste is generated in varying quantities, from receiving to incubation. However, the area with the most variables is from the methods of production. Figure 4.5 is a fishbone diagram showing the cause and effects of flavor and fruit losses.

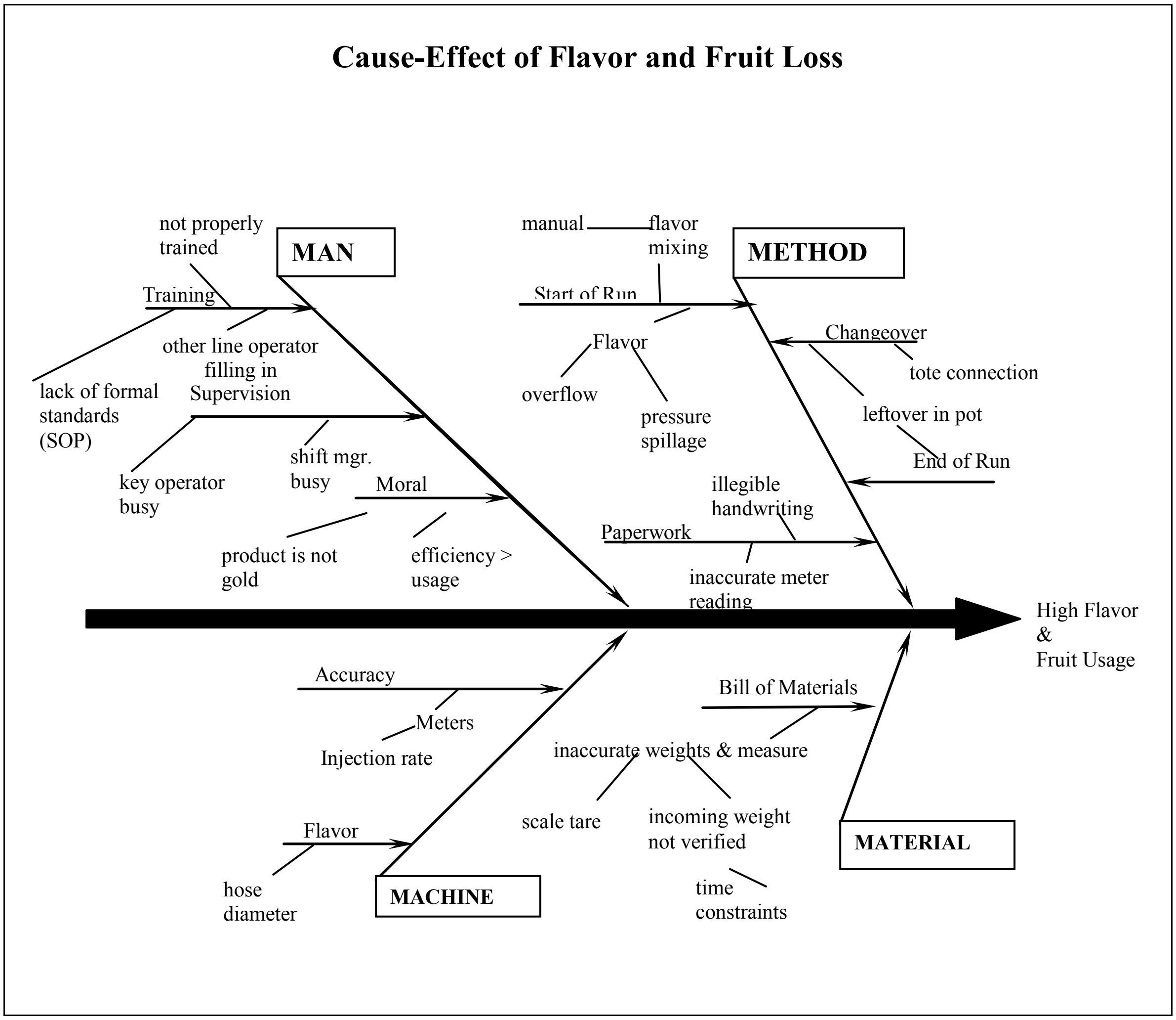

Figure 4.5 – Fishbone Diagram of Areas of Flavor & Fruit Loss

The different ways waste is generated is catalogued in fishbone diagram. The information illustrated in the fishbone diagram was information acquired through an eight-month long cooperative opportunity experience, in which the student worked full-time in the Operations Department of Stonyfield Farm as an industrial engineering intern.

The cause-effect information was generated through observational studies of operators in various departments- Raw Processing, Production, and Incubation. These observations involved spending time with an operator of each department for a full day, noting the physical processes, such as movement of materials, and mental processes, such as filling out paperwork tracking data, as well. Speaking with the operators on the floor was also helpful in gaining insight to operations, how and why certain operations are performed the way they are done, and the issues, why they may occur and how they are resolved, which occurred during observations.

In general, there are few standard operational procedures in place for operators to follow. While there is a changeover standard procedure in existence, there are no quantified objectives in how to perform this operation. In the packaging department alone, at least $4000 worth of fruit is disposed of each day through frequent and high volume flavor changeovers. During a single changeover, one operator may purge 100 gallons of fruit waste, whereas another purges only 30 gallons. Additionally, operators are more concerned with changing over a product in a timely manner rather than how much fruit is being wasted, as their production number is the final measurement of their day's performance.

Although it is a highly detailed job with varying tasks to keep in mind, there is no formal training for the position of filler and packer operator. All operators perform their own procedure for performing an operation, whether it be a changeover or starting up the line. Different operational procedures results in varying levels of waste generated by each operator, even though it may be the same process.

4.4 Line Observations

Observations of changeovers on Line 32 and Line 34 were conducted from February 13 through March 13. The operators of both lines were observed, with each operator's operational procedure broken into stages. The time to perform each step was recorded with a stopwatch. The quantity of waste generated from each step was captured in a three gallon container, later weighed on a scale.

4.4.1 Changeover Cases

Table 4.3 lists the different combinations of changeover procedures which may occur for the three types of flavors- fruit, liquid, and syrup. In Column one, labeled "Case", are the numbers used in reference to each specific case, depend on the initial and final flavor of the changeover being performed.

Changeover Cases

Case	Flavor		Base/Milk
	Initial	Final	
1	Flavor^1	Flavor^2	Same
3	Fruit^1	Fruit^2	Same
5	Flavor	Fruit	Same
7	Fruit	Flavor	Same
8	Fruit	Flavor	Different
9	Syrup	Flavor	Same
10	Fruit	Syrup	Same
11	Flavor	Syrup	Same
12	Syrup	Fruit	Same

Table 4.3 – Changeover of Flavor, Fruit, and Syrup Cases

4.4.2 Line Operators

The operators of each line and shift are given in Tables 4.4 and 4.5. The assembly lines run twenty-four hours a day, seven days a week. The only instances where a line may be down would be for a cleaning in progress (CIP) procedure, Sanitation, or for maintenance work.

Line 32 Operators

Line 32	White Shift		Blue Shift	
	Filler	Key	Filler	Key
Day	Bi	Ern	J	Ne
Night	Ni	W	M	Br

Table 4.4- Operators of Line 32

Every four hours, a sanitation procedure is performed by the operator; each line automatically shuts down for 10-15 minutes. The operator scrubs the milk and fruit fillers free from buildup and debris, and then the line automatically rinses itself and starts running.

The assembly lines go down every twenty-four hours for a period varying from two to three hours to perform a required procedure, CIP. The operator takes apart pieces of the line, individually scrubbing and soaking the pieces in a cleansing solution. The line rinses itself free of buildup and debris before the operator reassembles the pieces onto the line.

Line 34 Operators

Line 34	White Shift		Blue Shift	
	Filler	Key	Filler	Key
Day	R	Ern	M	Ne
Night	Eri	W	D	Br

Table 4.5 Operators of Line 34

Two shifts, White and Blue, rotate work schedules throughout the week. Each shift is broken into a Day Shift, from 7AM-7PM, and a Night Shift, from 7PM-7AM. The main individual responsible for each line is the Filler Operator. There is one filler operator for each line on each shift. In addition to the filler operator is the Key Operator. Key Operators oversee and assist the filler operators for two lines; Lines 32 and 34 typically are assigned to the same Key Operator due to the similarities of products produced from both lines.

4.4.3 Changeover Standards

Operators are given a standard of how much time it should take to perform specific changeover procedures; this standard is located in the back of the CUTE sheet.

Changeover Standards

	Base (min)	
Type	**Same**	**Different**
Liquid	10	12
Fruit	11	13
Syrup	12	14

Table 4.6 Changeover Standard Times

If an operator takes more time than is allotted to perform the procedure, only then are they required to record information to attribute as to why it took more time than necessary to perform the operation. The lack of a standard when it comes to flavor waste generated does not hold filler operators accountable to the amount of created.

4.4.4 Line 32 and Line 34 Characteristics

Lines 32 and 34 both manufacture 6 oz cup products; however both lines have inherently different operating characteristics (see Table 4.7).

Line 32 and Line 34 Assembly Lines

Line	32	34
Description	**Modern**	**Modern**
Model #	**MP358**	**MP480**
Product	6 oz	6 oz
Installed	1994	1992
per stroke	12	6
strokes/min	22.3	35.1
cups per min	267.6	210.6
Cups per case	12	12
lbs/cup	0.375	0.375

Table 4.7 Line 32 and 34 Assembly Line Characteristics

Line 34 was one of the first 6 oz cup assembly lines installed at Stonyfield Farm, in 1992. It produces six cups per stroke, set at 35.1 strokes per minute. This line is set to produce up to 210.6 cups per minute when the line is running at its most optimal level of efficiency with an attentive and responsive operator, and without any maintenance issues.

Line 32, installed in 1994, is set for less strokes per minute, however it produces 12 cups per stroke. As a result, overall this line produces a greater quantity of 6 oz cups than Line 34. Line 32 produces 267.6 cups per minute, versus line 34 at 210.6 cups per minute.

Based upon past experiences, syrups such as chocolate run better on Line 34 than 32 in regards to usage. Syrups have been observed to leak out of the fruit valves and splatter outside of the cup on Line 32. The usage numbers which quantify the amount of flavor used, per the schedule quantity, frequently indicated the usage of chocolate on Line 32 was greater than on Line 34. Therefore, Line 34 is always scheduled to run chocolate and only in rare instances where it cannot be avoided due to scheduling and demand is chocolate run on Line 32.

While both lines are different, they essentially require the same steps to perform a changeover.

4.4.5 Line Observations Data

The amount of waste generated during observed changeover processes are shown for Lines 32 (Table 4.8) and 34 (Table 4.9). The observations were made from the period of February 13th through February 28th. Observations were based operators of the day shift for both Blue and White Shift.

Line 32 Changeover Usage

LINE 32	START			END			Operator	Case	Start Time	End Time	Total Time (min)	Start Flavor Usage (gal)	End Flavor Usage (gal)
Date	SKU	Base	Flavor	SKU	Base	Flavor							
2/28	468	WM	Strawberry	461	WM	Blueberry	J	3	2:32PM	2:38PM	6	15	15
2/26	4016	LF	Blue/Straw	4002	LF	Vanilla	Bi	7	3:22PM	3:33PM	11	15	-
2/23	4016	LF	Blue/Straw	4001	LF	Blueberry	J	3	3:03PM	3:07PM	4	15	15
2/22	44	NF	Blueberry	49	NF	Lemon	Bi	7	5:45PM	5:55PM	10	25	-
2/21	41	NF	Strawberry	44	NF	Blueberry	Bi	3	3:10PM	3:15PM	5	25	25
2/19	197	LF	Blue/Straw	4004	LF	Maple Vanilla	J	10	1:45PM	1:54PM	9	15	-
2/19	4004	LF	Maple Vanilla	4005	LF	Raspberry	J	12	5:50PM	5:58PM	8	20	20
2/13	4002	LF	Vanilla	198	LF	Blue/Straw	Bi	5	1:00PM	1:11PM	11	20	20

Table 4.8 Line 32 Changeover Usage Data

Line 34 Changeover Usage

LINE 34	START			END			Operat or	Case	Start Time	End Time	Total Time (min)	Start Flavor Usage (gal)	End Flavor Usage (gal)
Date	SKU	Base	Flavor	SKU	Base	Flavor							
2/26	4003	LF	Mocha	4002	LF	Vanilla	Ne	1	4:42PM	4:46PM	4	15	-
2/23	4008	LF	Peach	4001	LF	Blueberry	M	3	5:14PM	5:20PM	6	20	50
2/22	4005	LF	Raspberry	4006	LF	Strawberry	R	3	3:38PM	3:43PM	5	15	20
2/21	468	WM	Strawberry	461	WM	Blueberry	R	3	1:40PM	1:46PM	6	15	20
2/21	461	WM	Blueberry	57	LF	Chocolate	R	10	4:11PM	4:19PM	9	20	20
2/21	57	LF	Chocolate	40	LF	Fr. Vanilla	R	9	6:10PM	6:21PM	11	20	-
2/20	464	WM	Vanilla	4001	LF	Caramel	M	11	6:01PM	6:11PM	10	20	20
2/13	45	LF	Blk Cherry	4002	LF	Vanilla	R	7	3:44PM	3:54PM	10	20	-

Table 4.9 Line 34 Changeover Usage Data

The starting flavor and the end flavor are each assigned a specified type according to whether fruit, flavor, or flavor syrup is being changed; a summary of each operational type is found on Table 4.3.

The total time the changeover process took was tracked with a stopwatch. The amount of usage generated from the ending flavor and the start flavor were collected in buckets and later calculated to determine the usage from each flavor type

Overall Usage Summary

Case	Initial	Final	Base	Avg Usage (lbs)	Avg Time (min)
1	Flavor A	Flavor B	Same	15	4
3	Fruit A	Fruit B	Same	30	5.5
5	Flavor	Fruit	Same	40	11
7	Fruit	Flavor	Same	30	10
9	Syrup	Flavor	Same	20	11
10	Fruit	Syrup	Same	40	9
12	Syrup	Fruit	Same	40	8

Table 4.10 Line 34 & Line 32 Average Usage Summary

4.5 Interviews

Interviews were conducted with day shift filler operators and key operators of both blue and white shift. Operators broke down the steps involved for each different type of changeover process they perform in accordance to the production schedule for their respective lines.

4.5.1 Fruit to Fruit Changeover

There are two methods to perform a Fruit to Fruit changeover (Case 3, Case 4). The first method is a fruit push, in which the changeover is performed by replacing the previous fruit tote with the upcoming fruit tote. The old fruit is pushed out of the piping by the new fruit. The fruit push is performed until all signs of the old fruit are non existent- color, texture, or fruit seeds if applicable. The second method is a water push, in which the fruit tote to be change is disconnected and the piping is flushed through with water until all signs of the old fruit are cleared. From there, the upcoming fruit tote is connected and the fruit is purged until the flow of the fruit is consistent.

Generally, the fruit push method uses more fruit in the changeover processes and takes approximately 7 minutes. The water push takes a considerably greater amount of time at about 10 minutes due to the additional process of connecting and disconnecting the waterline and other minor setup changes. However, less fruit is used during this changeover process as it is not as subjective as the fruit push where the operator determines whether the old fruit has cleared and the new fruit is fit for running on the line.

4.5.2 Fruit to Liquid Flavor or Flavor Syrup Changeover

The fruit to flavor changeover process is essentially the same as the water push process. The connections for the fruit tote are removed and the piping is connected to a waterline to flush remnants of the fruit out until the water appears clear. During the time the water is running to clear the piping, the operator typically sets up the new flavor by bringing the flavor tote or pallet of flavor buckets over makes the necessary connections. A flavor tote is given an attachment in which the operator twists a handle and the flavor flows into a flavor pot for flavoring. A pallet of flavor buckets, for flavors such as Key Lime and Maple, is dispensed to the line by the operator opening each individual bucket and pouring the flavor into the same flavor pot.

When the piping is cleared of the old fruit and the connections are made, the flavor is pumped and blended with the base (milk), and the operator runs the set amount of 120 gallons of down the drain to heat the milk and ensure the flavor has properly blended with the base.

4.5.3 Liquid Flavor or Flavor Syrup to Fruit Changeover

The flavor to fruit changeover is similar to the Fruit to Flavor Changeover except performed backwards, and the amount of usage generated differs. When the line has produced the amount of cases required for the run, operators are instructed to run the remaining flavor in the pot until it is empty or reasonably empty; there is no set quantity for reasonably empty. The connections to the flavor pot are removed and any remaining flavor goes down the drain. The operator connects the fruit tote to the line and purges the fruit until a consistent flow is observed.

5. ANALYSIS

As a result of interviews with the filler line operators and observations made on each line during changeovers, a standard for the fruit to fruit changeover usage has been identified at thirty pounds of fruit. Additionally, the high variance of fruit distributed to each cup by each filler head as identified with the fruit capabilities study, indicating the need for an updated filler head distribution system for better control of the dosing of fruit into individual cup.

5.1 Standardizing Changeover Usage

A standard for the fruit to fruit changeover usage has been identified at thirty pounds of fruit. The multiple observations on the line during the changeover process indicated usage from a changeover varied from thirty to fifty pounds. In the observation where fifty pounds of fruit was used during the fruit to fruit changeover process, the operator continued to purge fruit into the bucket even though the stage of purging could have been stopped earlier in the process at thirty pounds. It was observed that thirty pounds was the average baseline usage in order to properly change the fruit over without leaving any residue and generating an excessive amount of fruit waste.

5.1.1 Cost Benefit Analysis- Fruit Changeover Procedure

The cost benefit analysis compares the cost of the two most frequently occurring changeover processes- the fruit push and the water push method. In Table 4.12, data on both Line 32 and Line 34's production capabilities are provided to determine the quantity of cups that may be produced per minute. This is compared to the methods of fruit and or flavor changeovers via the water push and fruit push method.

Cost-Benefit of Line 32 and Line 34

				Water Push		Fruit Push	
Line	**Speed**	**Cups**	**Cups/Min**	**Fruit Usage (lbs)**	**Time Usage (min)**	**Fruit Usage (lbs)**	**Time Usage (min)**
32	22.3	12	267.6	25	10	75	5
34	25.1	6	150.6	25	10	75	5

4.11 Cost Benefit Analysis of Line 32 and Line 34

A cost benefit analysis of both the fruit push and water push method was done for Line 32 rather than line 34, as it produces the most cups per minute, at 267.6 cups versus 150.6 cups. The formula for calculating the net dollar amount loss due to usage is based upon each cup set at producing a profit of $0.30 each, with the average operational efficiency of Line 32 at 65% (Group Danone, 2006) Line 32 is capable of producing 267.6 cups per minute at 100% operational efficiency.

P [(OE * R) * T] = Loss due to Time

P = Profit Per Cup
= $0.30

OE = Operational Efficiency
= 65%
= 0.65

R = Production Rate
= 267.6 cups/min

T = Time to perform changeover
(average time based on observations)

Profit Loss Due to Water Push Time

T = 10 minutes

$0.30 [(0.65 * 267.6 cups/min) * 10 min] = $ 521.82

Profit Loss Due to Fruit Push Time

T = 5 minutes

$0.30 [(0.65 * 267.6 cups/min) * 5 min] = $ 260.91

In performing the water push method over the fruit to fruit push, the loss in production time, five minutes, results in the loss of $260.91 in potential sales profit.

= Water Push time loss – Fruit Push time loss
= $521.82 - $260.91
= $260.91

The savings in performing the water push over the fruit push, saving 25lbs of fruit per changeover, results in $34.50.

F = Fruit Push Usage
= 75lbs

W = Water Push Usage
= 50lbs

C = Average Cost of Fruit
= $1.38/lb

= (F - W) * C
= (75lbs - 50lbs) * $1.38/lb
$ 34.50

In comparing both methods, performing the fruit push method over the water push method is most optimal. The addition of five minutes in performing the water push results in the loss of $260.91, versus simply performing the fruit to fruit push method and using an additional twenty five pounds of fruit, or $34.50.

5.1.2 Standard Quantity for Fruit to Fruit Push Changeovers

For fruit to fruit pushes, the standard weight of usage generated from the changeover process should be at 30lbs. This will set the baseline standard for an acceptable amount of usage to be generated when a changeover is performed. Filler operators are to purge the maximum of 30lbs of fruit during a changeover procedure. Variance to this baseline standard must be identified and the root cause for this must be identified in order to prevent over usage to occur during a subsequent changeover.

5.2 New Fruit Dose System

As a part of their job functions, filler operators check the weight of each cup every fifteen minutes to obtain the current distribution rate of fruit per cup. The quantity of fruit or flavor per gram distributed in each cup varies; these variations in fruit distribution are inherent in the assembly machine itself. If a cup is identified as being not at the target weight for fruit or flavor, the filler operators manually adjust the fruit valves to bring the weight up to standard. Typically, operators find themselves adjusting the valves down, as too much fruit is being distributed into each cup. In order to verify the variability of fruit distributed into each cup, a study was performed on each filler head on Line 32.

5.2.1 Fruit Capabilities Study

A fruit capabilities study was performed on Line 32, in which each filler head produced fifty cups each containing fruit dispensed from the line into the cup. The line ran as is without any adjustments made to the fruit valves to control the weight. A sample of cups were weighed to determine the average cup weight of 7.15grams. The data captured on each cup's fruit weight distributed by the filler head is summarized in Table 4.11.

Line 32 Fruit Dosage Weight (g) by Filler Head

	Filler Head											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Average	52.3g	53.0g	47.5g	47.6g	45.2g	52.0g	54.1g	56.7g	49.0g	46.8g	48.1g	48.5g
Max	58.0g	74.0g	66.3g	80.0g	66.3g	62.6g	80.0g	110.8g	62.0g	55.7g	65.6g	65.9g
Min	49.0g	3.0g	5.0g	7.0g	9.0g	11.0g	48.2g	39.5g	43.9g	43.6g	44.1g	43.2g
Spread	9.0g	71.0g	61.3g	73.0g	57.3g	51.6g	31.8g	71.3g	18.1g	12.1g	21.5g	22.7g

Table 4.12 Line 32 Fruit Dosage Weight (g) Summary

From the fruit capabilities study, the average weight of fruit distributed into each cup ranges from 45.2 to 56.7 grams. The average per cup was 50.95 grams, which is 16.95grams greater than the set requirement of 34 grams of fruit per cup. The maximum and minimum weights overall vary from 3.0 to 110.8 grams.

5.2.2 No Fill Cups Reported Consumer Complaints

In addition to the variation of fruit distributed in each cup by the line are cups in which no fruit goes into the cup. As with the variation in fruit weights per cup, the lack of fruit in a cup is an issue inherent in the assembly machine in addition to the machine's age.

Line 32 Received No Fill Customer Complaints

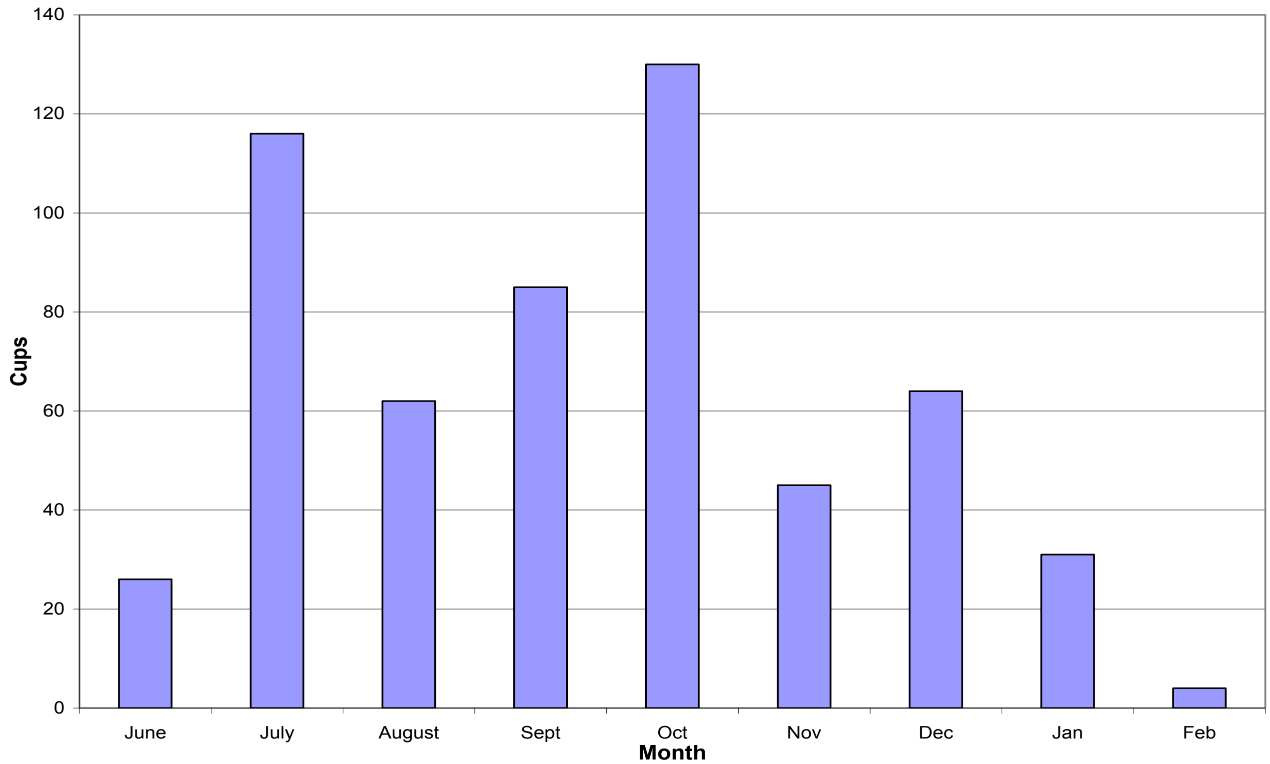

Table 4.13 Line 32 Received No Fill Customer Complaints

Table 4.12 is a collection of customer complaints received from June 2006 through February 2007; the date up until December 2006 is the most accurate reflection of consumer complaints received, as it takes anywhere from two to four months for a cup to be distributed to a consumer and a complaint to be received. Additionally, the received No Fill customer complaints do not reflect the actual quantity of no fill cups produced as not all consumers may report this production error.

Line 34 Received No Fill Customer Complaints

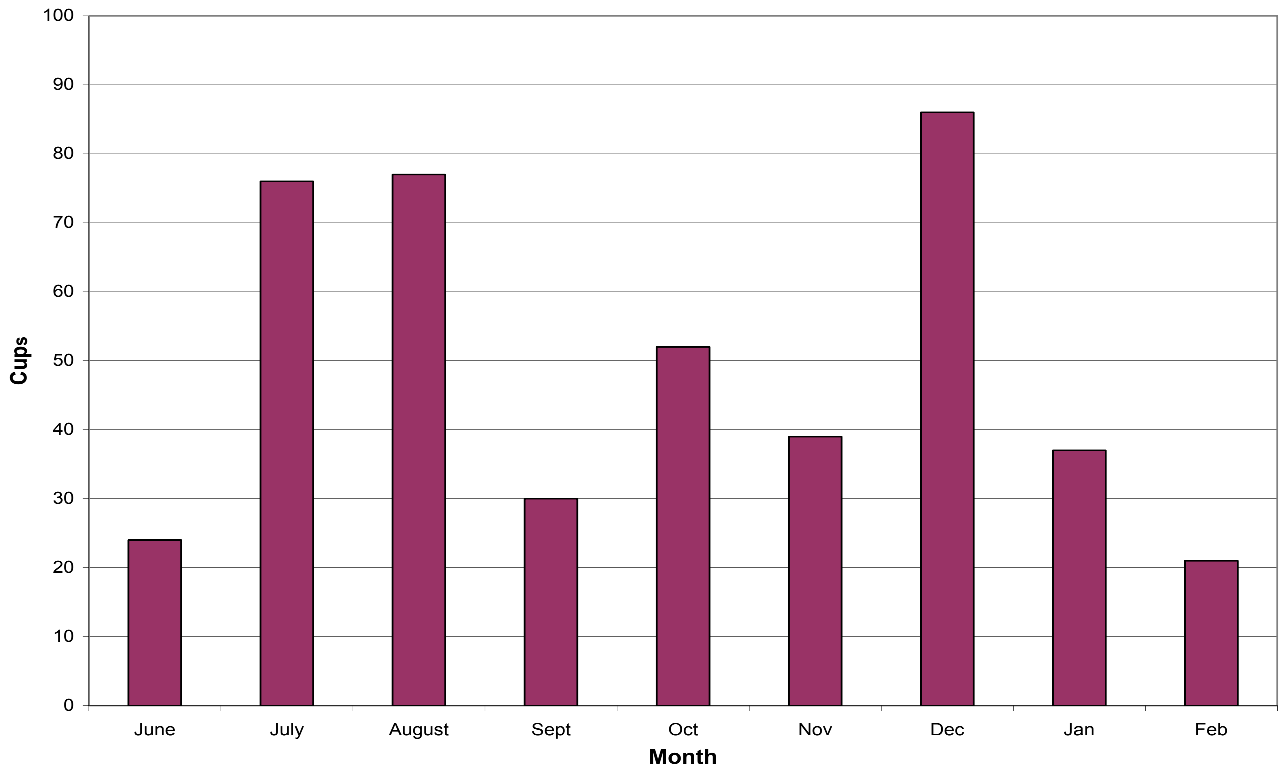

Table 4.14 Line 34 Received No Fill Customer Complaints

5.2.3 Description of Fruit Dose System

The Dosys Dosefruit System is "The benchmark for the injection of fruit into fresh dairy products" (Dosys, 2003). The benefits from the installation of this piece are plentiful, according to the supplier. Transition phases, such as changeovers, are improved to reduce fruit waste. Secondly, recipes can be changed without stopping the machine, and as a result reducing the amount of downtime and loss of production time. Additionally, Dosys provides more control on the distribution of fruit for various sized ingredients. Lastly, it is able to detect the bottom of containers; rather than having operators shake each tote to feel if it is light, Dosystem empties containers.

5.2.4 Cost of Fruit Dose System

A return on investment calculation compares the cost of a new feature with its resulting value; determining if the new feature is worth implementing. The cost for installation of the Dosystem may be found in Table 4.14

Replacement Fruit Dosing System Costs

Filler 32 Fruit Dosing System	**Supplier**	**Cost**
PROCESS MATERIAL		
Automatic Process Valves	TUCHEN	$6,792.05
Pump	FRISTAM	$19,474.46
Mixers and Others Process Special Equipment	ULTRAFILTER	$4,180.34
Instrumentation	E&H	$10,297.45
Piping Labor	*TIGPRO*	$14,617.83
Material- Tube	ALFA	$2,827.80
Equipment storage, rental	TIGPRO	$1,333.87
Mechanical field supervisor		$2,667.73
ELECTRICAL		
Electrical Studies	RICHARDSON	$640.26
Electrical labor	RICHARDSON	$15,206.08
Material	RICHARDSON	$8,626.33
Equipment rental, consumable …	RICHARDSON	$1,333.87
Electrical field supervisor		$2,667.73
Automation		$8,405.80
Design and Engineering		$7,222.22
Field Labor- Tests / Commissioning		$10,543.80
Transport of Equipment and Logistic for misc. components		$1,333.87
Travels- Project Manager, Field Technician, Automation		$7,322.86
Others: Training, Highlighted Diagrams, etc.		$588.24
Total Cost		**$126,082.58**

Table 4.15 Total Cost of Filler 32 Fruit Dosing System

According to the fruit capabilities study, when Line 32 ran without any adjustments on the fruit valves made by the line operator, an average of 16.95grams extra fruit was distributed into each cup. The total value of savings in fruit overfills by installing the Dosystem- which allows for more control over the dosing of fruit into cups-will be compared with the estimated cost for installing the Dosystem (Table 4.14) over a period of time to determine the breakeven point and when a return on the investment will ultimately occur.

Return on Investment= Benefits- Cost

Benefits= savings on fruit over usage (16.95grams/cup)

Cost= $126,082.58 (See Table 4.14)

*	24	hrs/day	
	-0.5	hrs/day	Sanitation
	-3	hr/day	CIP
	20.5	sub total of hrs/day running	
	13.325	total of hrs/day running at 65% OE	

** Average fruit cost of $1.20/lb

*** Usage per day based up on 13.25 hrs/day running at 65% OE

5.2.5 Return of Investment of Dosystem

Table 4.15 and 4.16 contain data on the expected breakeven point in which the savings from the addition of the Dosystem pays for itself through savings in overfilling cups with fruit. The cost of fruit per pound was set at the average of $1.38.

Type	Cost
Organic Blueberry 8076	$ 1.44/lb
Organic Strawberry 8078	$ 1.33/lb
	$ 1.38/lb

Non-Operator Adjusted Line 32 Overfills

	Fruit Usage (g)*	Fruit Usage (lbs) *	Cost ($)**
cup	16.95	0.037417219	0.051636
stroke	203.4	0.449006623	0.619629
min	4535.82	10.01284768	13.81773
hour	272149.2	600.7708609	829.0638
Day***	3626388.09	8005.271722	11047.27

Table 4.16 Non-Operator Adjusted Line 32 Overfills (Fruit Capabilities Study)

For Table 4.15, the expected breakeven point on the investment is based upon the average quantity of fruit that is in excess of the average, 16.95 grams per cup from the Fruit Capabilities Study when there are no adjustments made on the fruit valves by the line operator. The lack of adjustments results in the over-usage of $11,047.27 worth of fruit is distributed into cups per day.

$$\frac{\text{Cost of Dosys}}{\text{Usage per Day}} = \text{Number of days until Breakeven point}$$

$$\frac{\$\ 126{,}082.58}{\$\ \ 11{,}047.27} = 11.4 \quad \text{Days}$$

From this, the breakeven point in which the investment of the fruit dosystem pays for itself is at about eleven and a half days if Line 32 were to run at its typical operational efficiency of 65%.

Operator Adjusted Line 32 Overfills

	Fruit Usage (g)*	Fruit Usage (lbs) *	Cost ($)**
cup	3	0.006613873	0.009127
stroke	36	0.079366479	0.109526
min	802.8	1.769872485	2.442424
hour	48168	106.1923491	146.5454
Day***	641838.6	1415.013051	1952.718

Table 4.17 Operator Adjusted Line 32 Overfills

For Table 4.16, the expected breakeven point on the investment is based upon the average quantity of fruit that is in excess of the average, three grams per cup when adjustments made on the fruit valves by the line operator as needed when cups weights are checked every fifteen minutes. Even with adjustments made by the line operator, an excess of $1,698.02 worth of fruit is distributed into cups per day.

$$\frac{\text{Cost of Dosys}}{\text{Usage per Day}} = \text{Number of days until Breakeven point}$$

$$\frac{\$\ 126{,}082.58}{\$\ \ 1{,}952.718} = 64.5 \quad \text{Days}$$

From this, the breakeven point in which the investment of the fruit Dosystem pays for itself at sixty-four and a half days, or a little over two months of production time, if Line 32 were to run at its typical operational efficiency of 65%.

6. CONCLUSION

The research process conducted for this project resulted in the ability to determine the baseline standard for purging fruit during a changeover. Additionally, the best practice for a fruit and or flavor changeover on the 6 oz product lines of 32 and 34 was identified as the fruit to fruit push. The process was selected based upon a series of criteria set to minimize fruit and flavor waste and changing over in the least amount of time. Lastly, recommendations were made for updating the current fruit filler heads with a dosing system able to better control the distribution of fruit into each cup.

The baseline changeover usage quantity of fruit to be purged is thirty pounds. Changeovers observed on the line indicated a range of thirty to fifty pounds of usage purged during the process. Thirty pounds was the observed baseline in performing the changeover process, effectively purging remnants of the old fruit.

In comparing the fruit to fruit push versus water push for changeovers, the fruit to fruit push is the more time and cost efficient process. While the fruit tote method took five minutes less to perform than the water push, the value of time the five minutes lost was calculated to be $260.91. The fruit push method used an additional twenty five pounds of fruit at the cost of $34.50.

In updating the current fruit dosing system, an initial investment of approximately $126,000 would be made, seeing a return on its cost in a little over two months of production time.

The recommendations included in this paper will assist Stonyfield Farm in keeping its fruit and flavor usage during changeovers to a minimum in both cost of material and labor.

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