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Breakage Studies on French Fries

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BREAKAGE STUDIES ON FRENCH FRIES

by

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This independent study, submitted by Kalyan Dittakavi in partial fulfillment of the requirements for the Degree, Master of Science in Industrial Technology from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Title: Breakage Studies on French Fries.

Department: Industrial Technology.

Degree: Master of Science.

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Signature

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Date

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Dedicated To

Deepa YR

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ABSTRACT

This paper is a case study of French fry potato processing at the JR Simplot Food Group facility, Grand Forks, North Dakota. Broken French fries potentially reduce customer satisfaction with increased overhead costs to the company. This study examined a six-month on-site field investigation focusing on breakage of samples collected at different sample points for different types of cuts in the French fries processing.

The purpose of this study was to analyze and evaluate the percentage of the breakage occurred on French fries at different sample points for different types of cuts throughout the French fries process. Thereby conclude the area of concern on which corrective action should be taken to minimize the breakage on French fries samples.

The design of this study was to collect samples from all the sample points and analyze the data with respect to the length, breakage, and feathering, breakage being the area of concern. The findings of this study indicated a large percentage of breakage occurred at "after freezer" sample point for regular cut (13.45%), shoestring cut (10.03%), and thin cut (12.32%), and also a large percentage of breakage was noticed at "after blancher" sample point for crinkle cut (5.62%), and steak cut (11.40%).

The "after freezer", and "after blancher" sample points should be analyzed in detail for further studies as a large percentage of breakage occurred at those sample points.

CHAPTER I: INTRODUCTION

French fries are one of America's favorite potato side dish. "French fries account for more than one-fourth of all potatoes sold in the U.S. market—over six million pounds of potatoes are processed into frozen fries annually. Twenty-five percent of kids report eating French fries instead of other vegetables, and the average American eats thirty pounds of the greasy things in a year" (The secret, Para 12).

Most of the customers prefer unbroken French fries as their side dish. Breakage in French fries is an inevitable problem during processing. Although the breakage cannot be avoided to the full extent, taking corrective actions at the appropriate times can certainly reduce it.

This study was designed to address the breakage problems in French fries in a typical French fries processing facility, JR Simplot Food Group, Grand Forks, North Dakota. This study was a six months on-site investigation into the breakage of French fries. Samples of French fries were collected at uniform time intervals from different sample points for different types of cuts, at different sample points. The collected samples' length, number of breakage samples, and feathering information were entered into Microsoft Excel spreadsheets. After data was gathered for six months, analysis was performed to find the most breakage occurring sample point throughout the French fries processing.

NEED FOR STUDY

Breakage in French fries is a common phenomenon. Customers expect long, unbroken French fries with high quality. French fries processing is a complex process, which involves lots of machinery, time, manpower, and costs. To reduce the breakage in French fries is always one of the topmost quality assurance priorities of any company in the French fries business.

There was a need for this study because of the costs involved due to breakage of French fries. This study determined the percentage of breakage on French fries occurring at different sample points for different types of cuts and taking corrective actions to reduce the breakage of French fries at those particular sample point.

STATEMENT OF PROBLEM

The purpose of this study was to determine the sample point where most breakage occurred in the French fries processing by collecting samples of French fries from different sample points for different types of cuts. This study will be used as a tool by the JR Simplot Food Group facility to aid in the understanding where the most breakage occurred in the French fries processing and thereby take corrective actions to reduce the breakage.

OBJECTIVES

This study will help understand the percentage of breakage that occurs at different sample points throughout the French fries processing. The objectives of this study included the following:

- Determine the percentage of breakage at different sample points for different types of cuts in the French fries processing.
- Determine the percentage of feathering at different sample points for different types of cuts in the French fries processing.
- Identify the most breakage occurring sample point.
- Recommend measures to reduce breakage.

ASSUMPTIONS

This study was based on the following assumptions:

- Samples collected represent the whole population of cuts.
- Oil content, temperature, and blades used in cutting the potatoes are assumed to be consistent throughout the process.
- Sample trays and weighing instruments were consistent and accurate.

LIMITATIONS

Following limitations were considered in this study:

- This study was limited only to French fries produced at JR Simplot Food Group, Grand Forks, North Dakota.
- This study was limited to five types of French fry cuts.
- Samples were collected twice a day from seven different sample points -- after cutters, before blancher, after blancher, after dryer, after fryer, before freezer, and after freezer.
- The sample weight varied from one to two pounds.
- This study examined the percentage of breakage of breakage of French fries, not the reasons behind the breakage.

DEFINITION OF TERMS

The following are the definitions of terms used in this study:

Blancher: The container in which the French fries are carried through a large vat (or a few vats) of hot water. The time and temperature of the blanching is adjusted continually in order to remove access sugars and to give a consistent uniform color (MRHS Geography 421).

Dryer: French fries stay on the chain-belt and after they come out of the water, they go through another machine, which blasts hot air from both the top and bottom, partially drying the strips (MRHS Geography 421).

Extra long fancy: A USDA length specification indicating fries at least 30% of which must be over 3 inches, with less than 20% under 2 inches. These are the longest fries you can buy (Simplot Foods).

Feathering: Feathering is observed after handling potatoes and is a result of incomplete development of skin layer of potatoes.

Fryer: The frying is a cooking stage where the strips are cooked for about a minute and a half in oil that's a bit hotter than normal French fry cooking temperatures (MRHS Geography 421).

Freezer: Freezing is a method which freezes the French fries which travel down in the wire conveyor with air cooled down to about -40(Fahrenheit) so that only small ice crystals form and so they do not stick together (MRHS Geography 421).

Long fancy: A USDA length specification indicating fries at least 15% of which must be over 3 inches, with less than 30% under 2 inches. These are longer than line flow fries, but shorter than extra long fancy brands (Simplot Foods).

Sample: A set of French fries drawn from and analyzed to estimate the characteristics of a population.

Population: The set of French fries from which a statistical sample is taken.

USDA: United States Department of Agriculture. The federal department that administers programs that provides services to farmers (including research and soil conservation and efforts to stabilize the farming economy) (USDA).

Yield: The number of servings per case or per pound of fries. This is the single most important factor in fry profitability (Simplot Foods).

CHAPTER II: REVIEW OF LITERATURE

History of French Fries

History of French fries is dated long back. "Many possible claims as to the origin of "French fries" exist. Many attribute the dish to France, and offer as evidence a notation by U.S. President Thomas Jefferson. "Potatoes deep-fried while raw, in small slices" are noted in a manuscript in Thomas Jefferson's hand (circa 1801) and the recipe almost certainly comes from his French chef, Honoré Julien (1894 - Wikipedia, Para 2).

> "Belgium also claims to the origin of French fries. Jo Gerard, a famous Belgian historian, claims to have proof that this recipe for potatoes was already used in 1680, in the area of the Meuse Valley, between Dinant and Liège, Belgium. In 1861, a Belgian entrepreneur named Frits is said to have opened a stand selling this product. He is also said to have given it its own name, frites, which is the French name for the dish in Belgium. Even up to today every village in Belgium has several of these fries stands selling fries as the main dish and, in case you want something extra, a varied choice of fried meat products to go with it" (1894 - Wikipedia, Para 2).

"The Spanish claim for originating French fries credits the first appearance of the recipe to have been in Galicia, where it was used as an accompaniment for fish dishes, and from which it spread to the rest of the country and then to Belgium" (1894 - Wikipedia, Para 2).

French Fries Consumption

"Today, not only do French fries continue to be America's favorite potato side dish, but they are becoming one of America's most sizzling exports, as well. Consumption of French fries in the Far East has increased dramatically in recent years. In Japan, the largest importer of U.S. produced fries, consumption has increased by four times over the past 10 years. Consumption in Korea has risen 400 % in the past five years and tripled in Hong Kong over the last decade" (Idaho Potato, Para 4).

Americans have an insatiable appetite for French fries. "Each year more than 4.5 billion pounds of French fries are sold domestically. French fries were the best selling menu item in both commercial and non-commercial foodservice segments, according to Restaurants and Institutions 1993 Menu Census. Further" (Idaho Potato, Para 4).

"The U.S. is the third largest exporter of frozen potato products in value. In 2000, the U.S. exported 511,922 metric tons of frozen potato products, valued at $370 million. The largest foreign markets for U.S. frozen potato products are in Asia and the Pacific Rim, accounting for 84 percent of U.S. export volume in 2000. The largest single export market for U.S. French fries is Japan, accounting for 46 percent of U.S. fry export volume in 2000. The U.S. share of the Japanese frozen potato product import market rose from 84 per-cent in 1990 to a high of 90 percent in 1998, before falling to 85 percent in 2000. The recent decline in market share in Japan is the result of increased competition (particularly from Canada) and increased U.S. exports to other Asian and Latin American countries. Other major markets for U.S. frozen potato

products in Asia include China (11 percent of U.S. export volume, including Hong Kong), South Korea (7 percent), Taiwan (6 percent), and the Philippines (4 percent). In the Western Hemisphere, Canada and Mexico are the major markets for U.S. frozen potatoes with export shares of 3 and 6 percent, respectively" (Commodity Spotlight, Page 3). Refer to figure 7 for the five largest marketing years outside USA.

Customer Preferences

"McDonald's began making frozen French fries in 1966. In 1960 Americans consumed an average of about eighty-one pounds of fresh potatoes and four pounds of frozen French fries. In 2000 they consumed an average of about fifty pounds of fresh potatoes and thirty pounds of frozen fries. Today McDonald's is the largest buyer of potatoes in the United States. The taste of McDonald's French fries played a crucial role in the chain's success -- fries are much more profitable than hamburgers -- and was long praised by customers, competitors, and even food critics. On average, Americans now eat about four servings of French fries every week" (The Details Behind McDonald's, Para 1).

"Burger King Corporation serves about 1.7 billion units of French fries at the 8,300 restaurants in the U.S. each year. This amounts to approximately 600 million pounds of French fries" (Burger King, Para 5).

"The profitability of French fry business is highly related to the number of servings produced out of one case of frozen French fries. In a Quick Service Restaurant (QSR), a serving of French fries is measured and contained in a serving bag. For a

given size-serving bag, a medium serving size, for example, the amount of French fries you get from a QSR varies because they are measured visually rather than by weight. Because length effects how the bag fills, the length distribution of French fries in one serving bag will have a significant effect on the number of fries in the bag" (45E-3 Effect of French, Para 1).

Types of Cuts in French Fries

There are varieties of cuts in French fries processing. In general, customers prefer longer fries. It gives more servings per size than shorter fries.

"Longer fries will give you greater yield (servings per case) because it takes fewer of them to give the appearance of a full serving than it does with shorter fries. Extra long fancy signifies the longest grade of French fries; line flow the shortest. Greater yield always equals higher profitability" (Simplot Foods).

"The following are the different types of cuts used in French fries processing:

1. Straight cut
2. Shoestring cut
3. Crinkle cut
4. Loop cut
5. Wedge cut
6. Steak cut
7. Chip cut.
8. Thin cut" (Simplot Foods).

Figure 8 shows the different type of cuts. For the purpose of this study, sample data was collected on regular cut, shoestring cut, crinkle cut, steak cut, and thin cut only.

French Fry Process

"The processing of potatoes into French fries involves a variety of steps. The outline below is to inform the reader of some insight of taking a potato from the raw stage to the finished French fry. The following are 13 basic steps involved in the processing of French fries:

- Raw Product
- Peeling
- Inspection & Pre-Heat
- Strip Cutting
- Automatic Defect Removal (ADR)
- Blanching
- Dextrose
- Drying
- Frying
- Removing Excess Oil
- Freezing
- Grading
- Packaging

Raw Product

Raw potatoes undergo gradual changes from the day of harvesting until processing. The factors affecting finished product quality are reduction of sugars, size, specific gravity (percentage of solids) and cooking characteristics. Since these variables are changing throughout the processing season, it is essential to know the raw material to be processed.

The measuring of raw potatoes before processing, along with having knowledge regarding their processing characteristics, will eliminate production of non-uniform or off-grade finished product. Sampling of lots prior to processing to establish color uniformity, size, grade length and defects in respect to peel loss, trim loss and percent solids is imperative.

Peeling

A steam peeler works by heating the product surface to a high temperature for a predetermined length of time, and then the steam is exhausted rapidly causing a sudden pressure drop, which results in the breaking and separation of the skin from the potato. The potatoes are then fed into a brush type scrubber, which assists in removing any remaining skins. The last step is to further polish the whole potatoes in a brush or water type barrel washer. The steam peeler should be well monitored after peeling because the peeler can make one of the greatest impacts on finished potato recovery.

Inspection and Pre-Heating

After the barrel washer there is an inspection conveyor to remove obvious whole bad potatoes. The pre-heating of the whole potatoes was a great step forward to prevent the "shattering" or "feathering" of whole potatoes going through the cutters. The pre-heating also helps the life of the cutter blades in the cutter frame.

Cutters

Potatoes are pre-sized with a grader in the front of the cutters, one cutter for small potatoes and one for medium to large. The reason for sizing is that the cutters have a different size in the incoming orifice to give a more desirable long length to the cut potatoes.

Potatoes going through the water cutters are driven by high-pressure water, and go through a long 90° sweep elbow to centrifugally orient the potatoes length ways. The potato enters the module, which is a series of knives set to pre-determined specifications designed to give the desired cut while giving the maximum number of strips from the potato. The water module type knives are used for straight cut French fries, and mechanical cutters are used for crinkle and other cuts. Refer figure 9 and figure 10 for the cutting direction on potatoes.

Automatic Defect Removal (A.D.R)

The A.D.R.'s are a complex piece of equipment to automatically detect defects and remove them from the strips. The fries pass through a rapid optical scanner programmed to recognize defect color and shape. Each individual fry is scanned. The strips with defects are sorted out and then cutters selectively trim identified defects from individual strips.

Blanching

The blanching operation is used for uniformity of color control by extracting reducing sugars and is essentially a "surface phenomenon." Through the process of osmosis, the potato cell sugars pass through the cell membrane to the area of a lower concentration; the water in the blancher. If the concentration of reducing sugar would be allowed to increase in the blancher water, ultimately a state of equilibration would result, where no reducing sugars would be extracted from the potatoes and those potatoes of low reducing sugars would actually absorb some.

The water for the blancher is heated by means of a heat exchanger, pumped to the blancher spray headers, passed through the potatoes, out of the blancher's sloped floor through strategically located drains, passed through a totally enclosed screen filter and back to the heat exchanger.

It is important to realize that during the blanching operation the enzymatic control also is achieved. Unless the enzyme is arrested in this process step, it will show up in the finished product as gray or dark spots. The temperature required to cause enzymatic arrest is

160° to 170°F (70-75°C) and is seldom changed through the season. The time to raise the pulp temperature varies, depending on the thickness of the potato piece. The time to extract sugars can run as high as 25 minutes depending on the amount of sugar in the initial product. The blanch time and temperature should be closely monitored to avoid "sloughing" of edges on the French fry (end product should have sharp corners, not rounded).

Dextrose System

The purpose of dextrose systems, whether it is a dip tank, spraying or fluming is to add the final touch of color control. In blanching, primary concern was with color uniformity through leaching or extraction of sugars. The dextrose system establishes the shade or degree of finished color desired. The reconstructed finished product color is the final decision on color, and will establish the brix range required in the dextrose system, along with the degree of frying to achieve the different standards for color. Dextrose solutions are generally heated and maintained at 150°F to 170°F (65°C to 71°C) for solubility and prevention of souring due to bacteria.

Drying System

One of the most important pieces of equipment in the line is the dryer. The dryers for French fry processing come in single stage, two stage and three stage, revolving around production rate and finished solids. The temperature used for drying the strips should not exceed 185°F (85°C). A low running temperature is the most desirable for producing French

fries with exceptional texture. The low temperature approach eliminates problems with "case hardening" or "leathering" as described in the industry.

Single stage dryers can be used when the desired weight loss is in the 13% area. When the desired weight loss is 14% to 25%, then a two stage dryer is essential. The two stage dryer is accomplished by means of a transfer (unheated) section in the center of the dryer. The three stage dryer uses a second transfer between the second stage of the dryer and the equilibration stage.

The equilibration section is one of the most important steps in the art of drying French fries. The main purpose of the equilibration section is to allow the inner moisture to equilibrate through each strip so the moisture level is the same throughout. The ideal temperature for equilibration in the fries is maintained through the length of the section with a light steam spurge located under the conveyor belt. The roof of the equilibration section is peaked to prevent moisture condensation on the inner roof. The moisture runs down the inner roof and is discharged through drains in the floor of the section. Proper equilibration is very important to give the desired texture in a high solid French fry. The problem that some processors encounter is the potato strips sticking to the conveyor belts. Some manufacturers of dryers have recommended using a Teflon coating on the conveyor flights (a very expensive solution) instead of looking into the reasons for the sticking problems.

The drying step is very important to the amount of frying time. The now properly conditioned potato will require a minimal amount of time compared to a non-dried conventional type French fry.

Frying

The purpose of drying is three-fold, that is to develop color, improve texture and develop an outer skin. The control of this step is by a relationship of time and temperature with the size of cut being fried.

Temperature is the factor most influencing the color development utilizing the natural sugars and/or the dextrose solution applied to the strips prior to the drying stage. The browning effect from heat is known as the "mallard" reaction.

During frying, some of the frying oil enters the outer surface layer, and partially fills the void created by the loss of water. This absorption becomes the carryout and is replaced in the fryer constantly. The average absorption rate is approximately 4% that will cause a turnover period of the oil in approximate 6 hours.

It is important that the fryer is properly sized for the product flow or there will be considerable oil breakdown because carry out oil will effect the amount of oil entering the fryer, thus, in time, the oil will start to breakdown. There are several types of oil used in frying potatoes such as vegetable soya, palm oil, animal/vegetable blends, etc.

Cleaning procedures and proper filters should be followed very closely to make sure there is no residue left in the system causing scum, foaming of oil, etc.

Removing Excess Oil

There are several methods used to remove the surface oils to be used again in the fryer. Some methods used to remove the surface oil are by shaker, air nozzles, etc.

Freezing

Freezing is normally accomplished on a straight line tunnel that has a pre-cool and ambient air section, then quick freeze section (-20ƒF to -40ƒF) (-38ƒC). The speed of the stainless steel mesh belt to give correct bed depth, correlated to each individual cut size is important. Unless the bed depth is correct, air penetration cannot be accomplished and the result is "clustering" or unfrozen product.

Removing the excess surface oil is very important to give a quick freeze. Excess oil left on the strips forms a barrier as it solidifies, and in turn, slows down the temperature penetration.

Grading and Packing

The grading process in packaging is housed in the temperature controlled room where the grader will classify the material. The grading is capable of separating the extra long strips from the smaller length strips.

The packaging is a straightforward mechanical process with filling machines. Normally the grading will allow separate packaging for the extra long strips, and the other strips to another form of packaging" (French Fry Processing).

of the nation's largest producers of beef cattle, and ranks as a major manufacturer of agricultural fertilizers, with markets in the U.S., Canada, and Mexico"(Simplot Home).

"The Simplot food group is known for its quality frozen French fries and also for its consistency to produce quality based foods in food processing world. The firm also is one of the nation's largest beef-cattle producers, and ranks as a major agricultural-fertilizer manufacturer, with markets in the U.S., Canada, and Mexico"(Simplot Home).

Quality Standards for French fries

USDA Standards: As per the article 51.3410 of the United States Standards for grades of potatoes for processing and USDA, the following points are noteworthy:

Size: Unless otherwise specified, individual potatoes shall be not less than 2 inches in diameter or 4 ounces in weight. Also, the minimum size and the maximum size or range in size may be specified in connection with the grade in terms of diameter or weight.

Usable piece: Usable piece means that portion of potato remaining after trimming or as it occurs in the sample. It must have at least 50% of peel remaining after trimming.

USDA Specifications: The following specifications constitute the USDA Grade A Extra Long Frozen fries:

Extra Long: 30 % greater than 3" (7.5 cm)

80 % greater than 2" (5cm)

Long: 15 % greater than 3" (7.5cm)

70 % greater than 2" (5cm)

Medium: 50 % greater than 2" (5cm)

Short: 50 % less than 2" (5cm)

Generally, customers desire different lengths of French fries. For a given weight of French fries say, 5 pounds the final packed product will contain 40% of greater than 3 inch samples, 40 % 2-3 inch samples and 20 % of less than two inch samples. Basically these criteria change from customer to customer (United States Standards Potatoes for Processing).

JR Simplot Company Standards:

Quality standards at JR Simplot Company have a great significance at all levels of production. JR Simplot Company follows the guidelines prescribed by USDA. The company goals with respect to quality of frozen foods are as follows:

- To offer the finest quality and most extensive lines of frozen potato products anywhere, giving a wide range of cuts and flavor profiles with high quality and excellent profitability.
- Potatoes selected from the world's finest growing regions.
- Easy to prepare.
- High quality--meets or exceeds USDA Grade A standards.
- Consistent flavor and texture-specially grown and processed Simplot specifications.
- Quick to prepare and excellent hold characteristics.
- Wide variety of choices to match any menu need.

Quality Testing Standards:

There are twenty people employed in the quality assurance department in the Grand Forks facility. A sample is collected off the line and tested for compliance of the quality standards. Samples are collected at every half an hour. Quality testing procedures begin as soon as the raw potato comes into the facility. The following quality tests were conducted at different phases of processing:

- Weight
- Color
- Texture
- Specific gravity
- Length
- Percentage of breakage
- Feathering.

CHAPTER III: METHODOLGY OF STUDY

The design of this study is based on the quantitative analysis of the data obtained by collecting samples of French fries in a six-month period. The study has been carefully designed to provide an efficient evaluation of the percentage of breakage samples occurred at different sample points in the French fries processing at JR Simplot Company.

Procedure of the Study

The following were the key points in the procedure of this study, which will be detailed further in the following pages:

- Conduct an on-site field data gathering investigation
- Analyze the data for different types of cuts at different sample points
- Evaluate the percentage of breakage occurred at all the sample points for different types of cuts.
- Conclude the most breakage occurred sample point by grouping the data collected over the six month period for each type of cut at each sample point.

Data Gathering Instruments

The data gathering instruments used in this study were listed as follows:

- A steel tray on which different lengths (4 inch, 3 inch, 2 inch, 1 inch) are marked (Figure 11).
- A Weighing scale used to measure the weight of the collected samples. (Figure 12).
- Tray to collect samples of French fries. (Figure 13).

- Breakage study data in Microsoft word. Refer to appendix A to see Sample Breakage Study Data in Microsoft Word.
- Breakage study data in Microsoft Excel spread sheets. Refer to appendix B to see Sample Breakage Study Data in Microsoft Excel.

Data Gathering Procedure

- One to two pounds samples of French fries were collected from the different sample points (after cutters, before blancher, after blancher, after dryer, after fryer, before freezer, and after freezer) at different time intervals.
- The collected samples were analyzed according to their length (greater than 4 inch, 3-4 inch, less than 2 inch, less than 0.5 inch), number of breakages, and feathering. Data was collected on different types of cuts (steak, crinkle, shoestring, regular, and thin cut) depending upon the company's production requirement on a given date.
- The data collected was documented in Microsoft Word and Microsoft Excel for a given type of cut.
- The same procedure was repeated for six months to gain a better understanding of the data. Sample data gathering sheet can be found in appendix A.

Note: The sample data was collected for six-month period for each type of cut at each sample point with varying dates and varying time intervals. The collected data was grouped together for each type of cut and summarized according to the number of breakages occurred over the six-month period to conclude the most breakage

occurred sample point. This suggestion was adopted from the JR Simplot Company Management.

CHAPTER IV: ANALYSIS OF DATA AND FINDINGS

The samples of French fries collected from different sample points for different types of cuts for different sample sizes with varying sample weights at different time intervals were analyzed to determine where the most breakage occurred over the six-month period at JR Simplot Company. An analysis on breakage of French fries was performed by plotting the data collected in the six-month period using Microsoft Excel to find where the most breakage occurred.

Analysis of Breakage Data

Percentage of breakage occurred on the French fries for different types of cuts at different sample points will be detailed in the following pages. To see the data for a particular type of cut please refer to appendix C for regular cut, appendix D for crinkle cut, appendix E for shoestring cut, appendix F for steak cut, and appendix G for thin cut. The data was collected for five types of cuts, at seven different sample points, which are listed as follows:

Type of cut	**Sample Point**
Regular cut	After cutters
Crinkle cut	Before blancher
Steak cut	After blancher
Shoestring cut	After dryer
Thin cut	After fryer
	Before freezer
	After freezer.

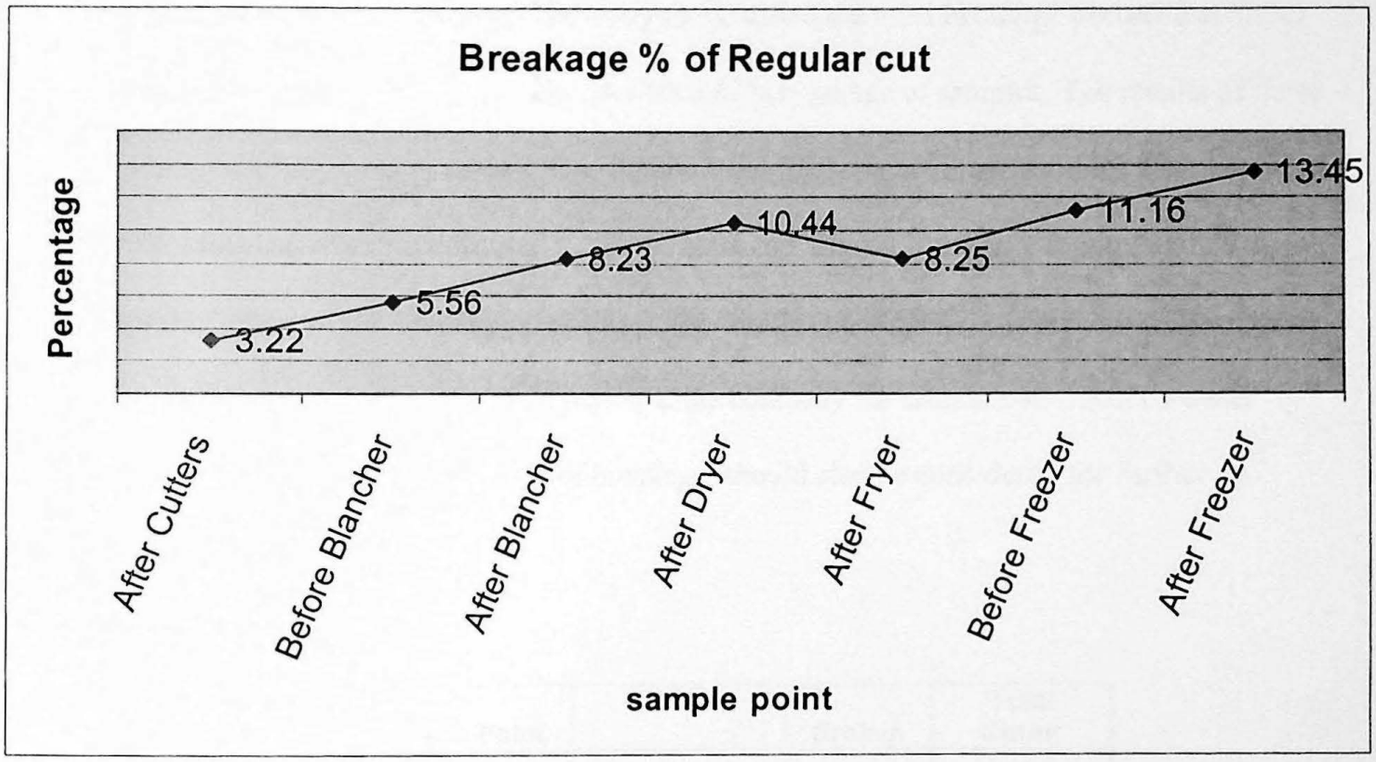
1. **Analysis and breakage percentage for Regular Cut fries:**

A thorough investigation was performed into the tabulated data by using Microsoft Excel spreadsheets and charts. The analysis identified the most breakage occurred at "after freezer" sample point for regular cut with 13.45 % breakage of samples. The results of these findings are tabulated in table1. Five hundred and five breakage samples were found in 3755 samples, which constituted 13.45% of breakage. Figure 1 provides a graphical representation of the breakage percentage for regular cut. Appendix C provides the original data collected over the six-month period at the company for regular cut.

Table1: Regular Cut

Sample Point		Broken	Total Count
After Cutters	Number	95.00	2950.00
	Percentage	3.22	
Before Blancher	Number	144.00	2591.00
	Percentage	5.56	
After Blancher	Number	245.00	2977.00
	Percentage	8.23	
After Dryer	Number	337.00	3229.00
	Percentage	10.44	
After Fryer	Number	306.00	3708.00
	Percentage	8.25	
Before Freezer	Number	421.00	3771.00
	Percentage	11.16	
After Freezer	Number	505.00	3755.00
	Percentage	13.45	
Total Count		2053.00	**22981.00**
	Mean	293.29	3283.00
	Std Dev	145.57	470.44

Figure 1: Regular Cut



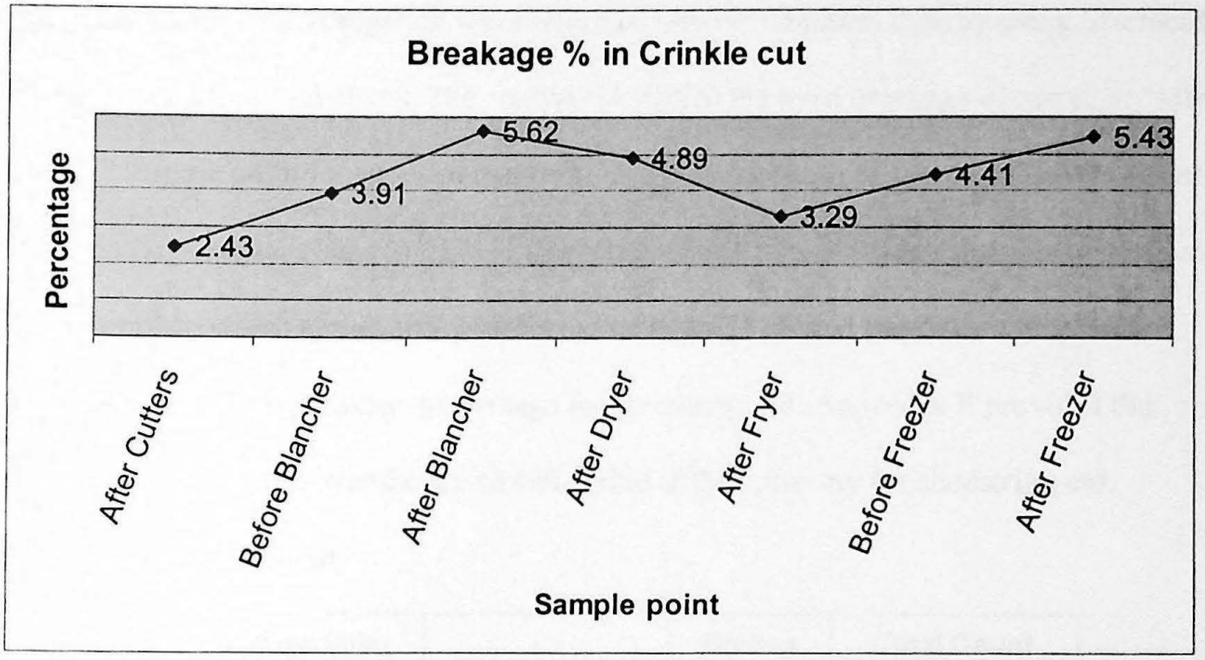
2. Analysis and breakage percentage for Crinkle Cut fries:

A thorough investigation was performed into the tabulated data by using Microsoft Excel spreadsheets and charts. The analysis identified the most breakage occurred at "after blancher" sample point for crinkle cut with 5.62% breakage of samples. The results of these findings are tabulated in table 2. One hundred and fifty one breakage samples were found in 2686 samples, which constituted 5.62% of breakage. Figure 2 provides a graphical representation of the breakage percentage for crinkle cut. Appendix D provides the original data collected over the six-month period at the company for crinkle cut. "After freezer" sample point, which has a 5.43% of breakage, should also be considered for further investigation.

Table 2: Crinkle cut

Sample Point		Broken	Total Count
After Cutters	Number	64.00	2632.00
	Percentage	2.43	
Before Blancher	Number	96.00	2453.00
	Percentage	3.91	
After Blancher	Number	151.00	2686.00
	Percentage	5.62	
After Dryer	Number	149.00	3046.00
	Percentage	4.89	
After Fryer	Number	109.00	3318.00
	Percentage	3.29	
Before Freezer	Number	143.00	3239.00
	Percentage	4.41	
After Freezer	Number	178.00	3276.00
	Percentage	5.43	
Total Count		890.00	**20650.00**
	Mean	127.14	2950.00
	Std Dev	39.10	354.09

Figure 2: Crinkle Cut



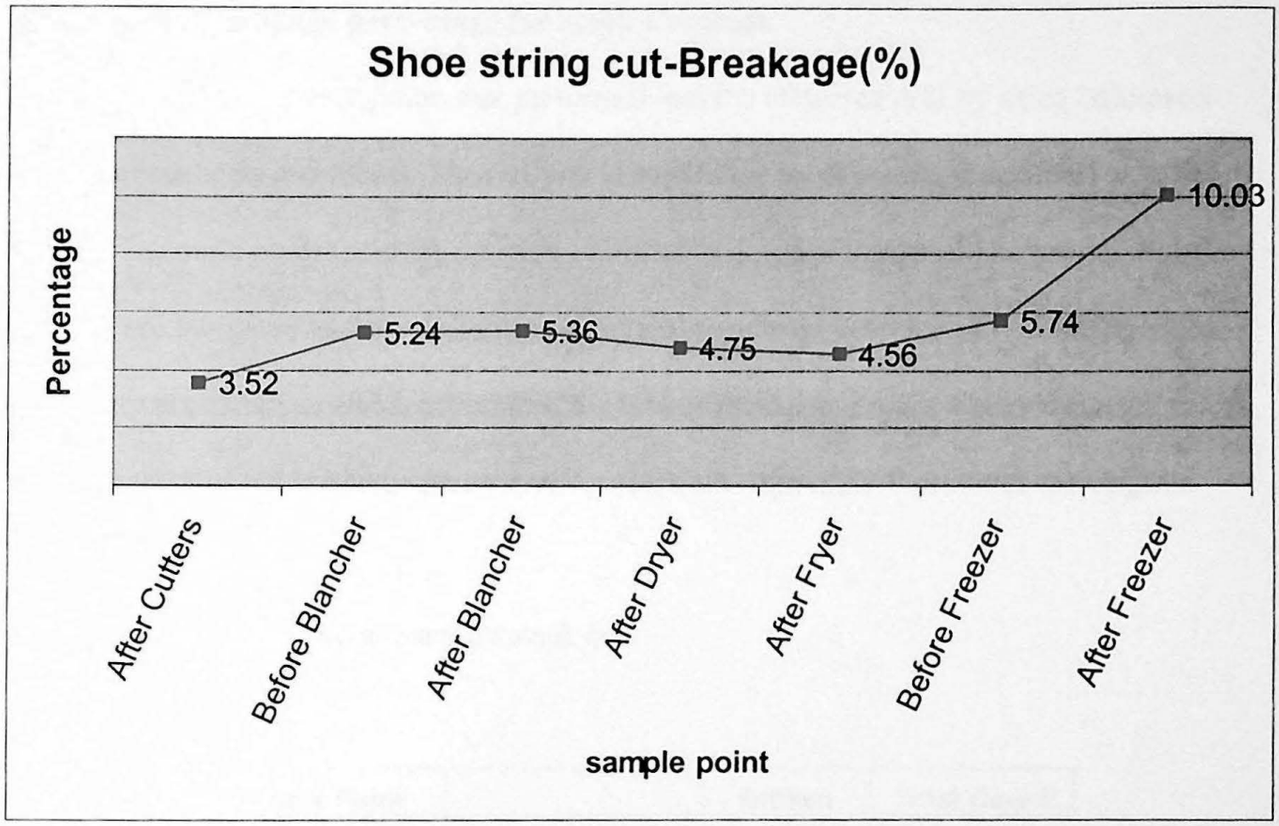
3. Analysis and breakage percentage for Shoestring Cut fries:

A thorough investigation was performed into the tabulated data by using Microsoft Excel spreadsheets and charts. The analysis identified the most breakage occurred at "after freezer" sample point for shoestring cut with 10.03 % breakage of samples. The results of these findings are tabulated in table 3. One hundred and fifty breakage samples were found in 1495 samples, which constituted 10.03% of breakage. . Figure 3 provides a graphical representation of the breakage percentage for shoestring cut. Appendix E provides the original data collected over the six-month period at the company for shoestring cut.

Table 3: Shoestring cut

Sample Point		Broken	Total Count
After Cutters	Number	37.00	1051.00
	Percentage	3.52	
Before Blancher	Number	54.00	1030.00
	Percentage	5.24	
After Blancher	Number	59.00	1101.00
	Percentage	5.36	
After Dryer	Number	58.00	1221.00
	Percentage	4.75	
After Fryer	Number	65.00	1426.00
	Percentage	4.56	
Before Freezer	Number	74.00	1289.00
	Percentage	5.74	
After Freezer	Number	150.00	1495.00
	Percentage	10.03	
Total Count		497.00	**8613.00**
	Mean	71.00	1230.43
	Std Dev	36.62	182.98

Figure 3: Shoestring Cut



4. Analysis and breakage percentage for Steak Cut fries:

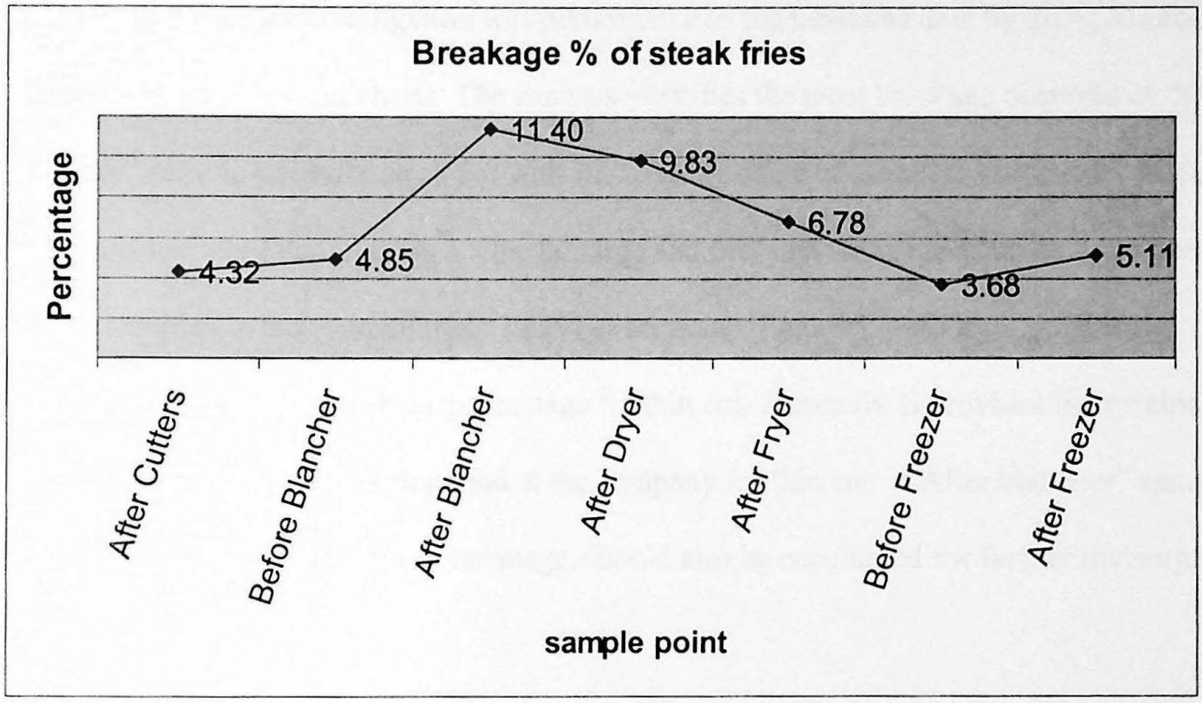
A thorough investigation was performed into the tabulated data by using Microsoft Excel spreadsheets and charts. The analysis identified the most breakage occurred at "after blancher" sample point for steak cut with 11.40 % breakage of samples. The results of these findings are tabulated in table 4. Forty-four breakage samples were found in three hundred and eighty six samples, which constituted 11.40% of breakage. Figure 4 provides a graphical representation of the breakage percentage for steak cut. Appendix F provides the original data collected over the

six-month period at the company for steak cut.

Table 4: Steak Cut

Sample Point		Broken	Total Count
After Cutters	Number	16.00	370.00
	Percentage	4.32	
Before Blancher	Number	20.00	412.00
	Percentage	4.85	
After Blancher	Number	44.00	386.00
	Percentage	11.40	
After Dryer	Number	40.00	407.00
	Percentage	9.83	
After Fryer	Number	36.00	531.00
	Percentage	6.78	
Before Freezer	Number	19.00	516.00
	Percentage	3.68	
After Freezer	Number	25.00	489.00
	Percentage	5.11	
Total Count		200.00	**3111.00**
	Mean	28.57	444.43
	Std Dev	11.25	65.84

Figure 4: Steak Cut



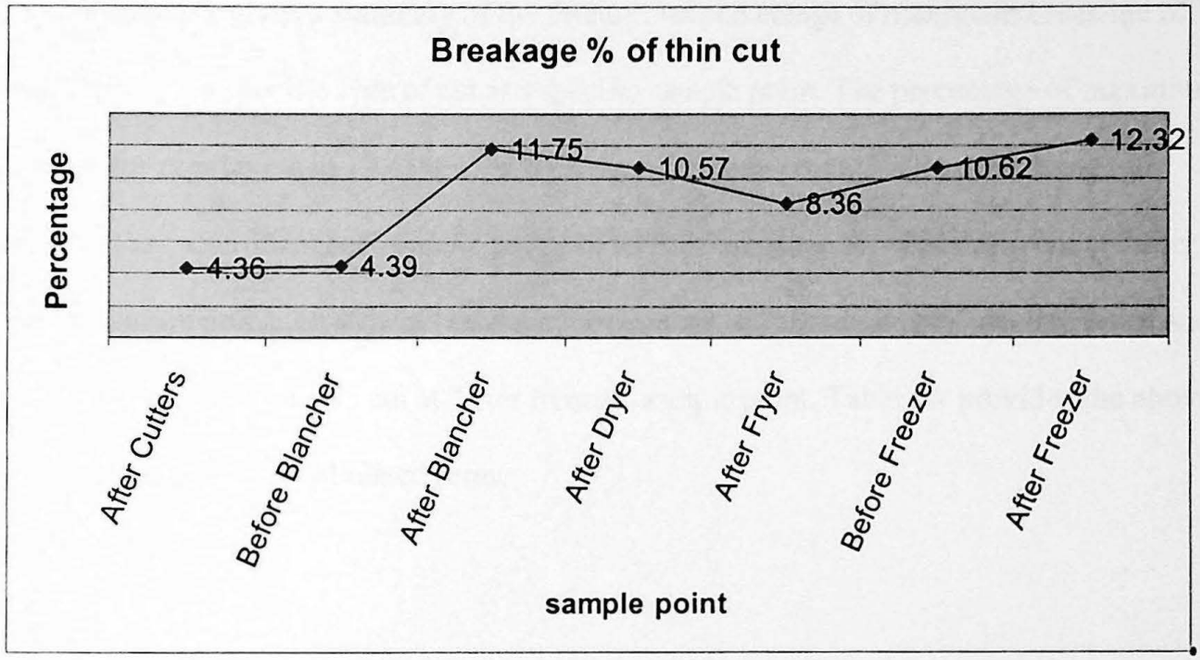
5. Analysis and breakage percentage for Steak Cut fries:

A thorough investigation was performed into the tabulated data by using Microsoft Excel spreadsheets and charts. The analysis identifies the most breakage occurred at "after freezer" sample point for steak cut with 12.32 % breakage of samples. The results of these findings are tabulated in table 5. One hundred and fifty one breakage samples were found in 1226 samples, which constituted 12.32% of breakage. Figure 5 provides a graphical representation of the breakage percentage for thin cut. Appendix G provides the original data collected over the six-month period at the company for thin cut. "After blancher" sample point, which has an 11.75% of breakage, should also be considered for further investigation.

Table5: Thin Cut

Sample Point		Broken	Total Count
After Cutters	Number	38.00	872.00
	Percentage	4.36	
Before Blancher	Number	37.00	843.00
	Percentage	4.39	
After Blancher	Number	102.00	868.00
	Percentage	11.75	
After Dryer	Number	108.00	1022.00
	Percentage	10.57	
After Fryer	Number	101.00	1208.00
	Percentage	8.36	
Before Freezer	Number	138.00	1300.00
	Percentage	10.62	
After Freezer	Number	151.00	1226.00
	Percentage	12.32	
Total Count		675.00	**7339.00**
	Mean	96.43	1048.43
	Std Dev	44.42	194.45

Figure 5: Thin Cut



Summary of Findings

Figure six gives a summary of the findings on percentage of maximum breakage of French fries for a specific type of cut at a specific sample point. The percentage of maximum breakage for regular cut is 13.45% at "after freezer" sample point, 5.62% of breakage for crinkle cut at "after blancher" sample point, 10.03% of breakage for shoestring cut at "after freezer" sample point, 11.40% of breakage for steak cut at "after blancher" sample point and 12.32% of breakage for thin cut at "after freezer" sample point. Table six provides the above-mentioned analysis in a tabulated form.

Figure 6: Summary of percentage of maximum breakage on different types of cuts

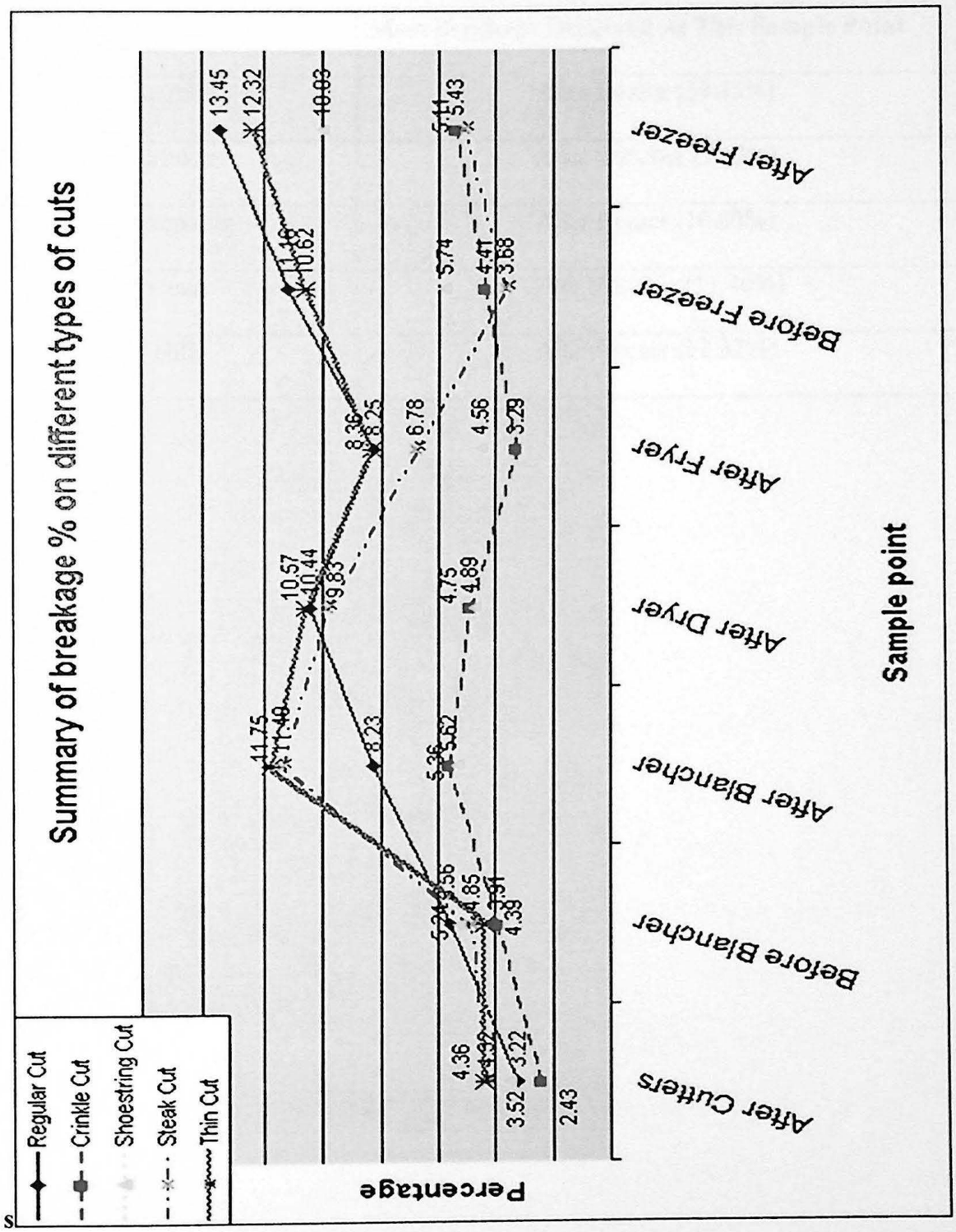


Table 6: Findings of Breakage Studies

Types of Cut	Most Breakage Occurred At This Sample Point
Regular	After freezer (13.45%)
Crinkle	After blancher (5.62%)
Shoestring	After freezer (10.03%)
Steak	After blancher (11.40%)
Thin	After freezer (12.32%)

CHAPTER V: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Restatement of the Problem and Objectives

The purpose of this study was to determine the sample point where most breakage occurred in the French fries processing by collecting samples of French fries from different sample points for different types of cuts. This study will be used as a tool by the JR Simplot Food Group facility to aid in the understanding of the most - breakage occurring sample point in the French fries processing and thereby taking corrective actions to reduce the breakage on the particular breakage sample point.

Summary

This study analyzed the breakage percentage for regular cut, crinkle cut, shoestring cut, steak cut, and thin cut at "after cutters", "before blancher", "after blancher", "after dryer", " after fryer", " before freezer", and "after freezer" sample points in a typical French fries processing facility, JR Simplot Company, Grand Forks, North Dakota. The maximum breakage percentage for regular cut is 13.45% at "after freezer" sample point, 5.62% of breakage for crinkle cut at "after blancher" sample point, 10.03% of breakage for shoestring cut at "after freezer" sample point, 11.40% of breakage for steak cut at "after blancher" sample point and 12.32% of breakage for thin cut at "after freezer" sample point.

Conclusions

The conclusions of this study is that a large percentage of breakage occurred at "after freezer" sample point for regular cut (13.45%), shoestring cut (10.03%), and thin cut (12.32%), and also a large percentage of breakage was noticed at "after blancher" sample point for crinkle cut (5.62%), and steak cut (11.40%).

Some of the reasons for breakage of French fries which were observed and gathered from the lab supervisors, co-workers, and the management of the JR Simplot Company, may include, but are not limited to:

- Poor blade quality
- Potatoes quality
- Excessive oil temperature
- Feathering
- Cutting process
- Tumbling, and transition.
- Sugars, size, specific gravity, and cooking characteristics

Recommendations for Further Study

Corrective actions should be taken at the "after freezer" and "After blancher" sample points where most breakage occurred. In order to maintain the quality standards in the company with regards to the breakage of the French fries, it is recommended that "breakage studies" be conducted periodically in the facility so as to identify the most breakage-occurring sample points and take corrective actions to reduce the breakage in French fries in the process. The above-mentioned reasons of breakage of French fries should be considered in detail when evaluating a further study so as to reduce the impacts of breakage costs to the company.

REFERENCES

Burger King 010652: Results of Burger Opinion Poll. Retrieved on October 3, 2005, from http://www.spcnetwork.com/mii/2001/010652.htm.

1894 - Wikipedia, the free encyclopedia. Retrieved on October 3, 2005, from http://en.wikipedia.org/wiki/1894

45E-3 Effect of French fry length distribution on number of servings. Retrieved on October 3, 2005, from http://ift.confex.com/ift/2003/techprogram/paper_20080.htm

Commodity Spotlight 8 Economic Research Service/USDA Agricultural Outlook/October 2002. Retrieved on October 3, 2005, from www.ers.usda.gov/publications/agoutlook/oct2002/ao295c.pdf .

French Fry Processing by Richard Eckard. The National Drying Machinery Company Philadelphia, Pennsylvania. Retrieved on September 20, 2005, from http://www.nationaldrying.com/abstracts/frenchfry/

Idaho Potato: French Fries. Retrieved on October 3, 2005, from http://radio.boisestate.edu/information/otherprojects/potato/fries.html.

MRHS Geography 421 - Potato Homepage. P.E.I. Potato Farming. French-fry Production. Retrieved on October 3, 2005, from http://www.edu.pe.ca/montaguehigh/geography/farming/index.htm

The Details Behind McDonald's French Fries 2/7/01. Retrieved on September 25, 2005, from http://www.mercola.com/2001/feb/7/french_fries.htm.

The secret history of French fries. Retrieved on September 29, 2005, from http://www.stim.com/Stim-x/9.2/fries/fries-09.2.html.

Simplot Foods. Retrieved on October 5, 2005, from http://www.simplotfoods.com/index.cfm? content=products&class_id=156

Simplot Home. Retrieved on October 3, 2005, from http://www.simplot.com/

United States Standards for Grades of Potatoes for Processing. Retrieved on October 3, 2005, from http://www.ams.usda.gov/standards/vppot.pdf.