Supply Network and Operations Analysis in the UK Food Industry

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Contents

Introduction

The food and drink processing industry is the fourth highest industrial energy user in the UK, it is also one of the largest users of refrigeration technology with many businesses within the sector finding that refrigeration costs make up a significant proportion of their energy bill (The Carbon Trust, 2006).

This report is part of larger project titled 'fostering the developments of technologies and practices to reduce the energy inputs into the refrigeration of food'. The overall objective of the project is to identify, develop and stimulate the development and application of more energy efficient refrigeration technologies and business practices for use throughout the food chain.

The project has four partners:

1. The University of Bristol's Food Refrigeration and Process Engineering Research Centre (FRPERC)
2. Brunel University's energy and built in environment research group (EBERC)
3. London South Bank University (LSBU)
4. University of Sunderland (AMAP)

This report is part of the University of Sunderland's specific role on operations and supply network configuration and design. The aim of this work was to analyse food manufacturing supply chains to identify areas where energy savings can be made through the reduction of refrigeration usage as a result of operations/supply network improvements whilst not compromising food safety and quality.

This report will:

- Discuss the development of instruments and tools used for data collection (WP1)
- Identify how the food supply chains studied were chosen (WP2)
- Describe how data was collected (WP3)

- Analyse the key areas of wastage in the food supply chains studied, which contribute to unnecessary refrigeration usage (WP4)

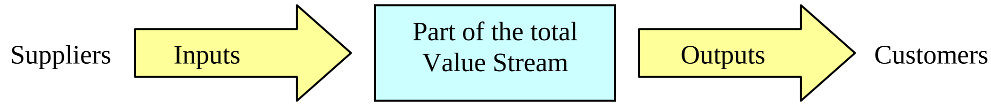
WP1 – Development of instruments and tools for data collection

Value Stream Mapping (VSM) was chosen as a tool to gather information on the food supply chain because it has been used successfully by many organisations to plan and identify internal improvements (Dolcemascolo, 2006). Furthermore when used appropriately it can help the process industry eliminate waste, maintain better inventory control, improve product quality, and obtain better overall financial and operational control (Abdulmalek, Rajgopal, 2005).

This tool has been used in previous work by Jones and Womack, 1996 & 2002. Rother and Shook, 2003, and Hines et al, 2000. Studies have mainly focussed on Value Stream Mapping in the manufacturing sector (Hines, Rick, Esain, 1998; Abdulmalek, Rajgopal, 2005; Seth, Gupta, 2005) and the flow for material and information in office activities (Tapping, Shuker, 2003; Swank, 2003).

Very few studies have focussed on Value Stream Mapping in the meat dairy, fresh produce and convenience food markets and to the authors knowledge value stream mapping has not been applied to energy usage in refrigeration.

Rother and Shook (1999) define VSM as a collection of all actions (value-added as well as non-value added) that are required to bring a product (or a group of products that use the same resources) through the main flows, starting with raw material and ending with the customer.



The ultimate goal of VSM is to identify all types of waste in the value stream and to take steps to try to eliminate these (Rother and Shook, 1999). Waste can be any part of the process that takes time and resources but adds no value to the product and can even include something as small as taking extra footsteps to bring a product to another part of the factory for finishing.

Hines, Rich, Esain (1999) discovered that for the vast majority of the time whilst products are within the defined supply chain no value is being added. Furthermore, in a recent study by The Food Chain Centre (2007) it was found that 20% of the food industries costs are non-value adding.

VSM is a paper and pencil tool, which is created using a set of icons (see appendix 1). The first step of VSM is to create the current state map to capture how things are currently being done and where improvements may lie. This is accomplished while walking along the actual processes, analysing the system and identifying weaknesses or waste (Abdulmalek, Rajgopal, 2005). Because the current state maps show the flow of materials, information flow and process timelines, they are a very effective method for communicating the key features of a process within an organisation (Taylor, 2005)

The second stage of VSM is the future state map, which is a picture of how the system should look after the inefficiencies in it have been removed. A future state map is created by answering a set of questions on issues related to efficiency. This map then becomes the basis for making the necessary changes to the system.

The aim of this project is to use value stream mapping to identify key areas of waste in food supply chains, which contribute to unnecessary refrigeration usage. On completion of the data collection, the objectives of the project are to:

- Understand the ‘current state’ of the supply chains for each of the companies studied.
- Identify key areas of waste, problems and opportunities across the supply chain within refrigeration.

- Develop a 'future state vision' of each of the supply chains
- To develop an 'action plan' to achieve the future state

WP2 – Identification and selection of 20 food supply chains, which are representative of the UK food sector.

The food supply chains chosen for the project were representative of the different sectors of the UK food sector and included meat, dairy, fresh produce, and convenience food manufacturers. Each company was chosen based on food type, equipment type, chain size and complexity. Table 1 identifies and compares the products each of the companies manufacture, the number of years each company has been in operation, the number of staff who work for the company, the size of the site the company operates on and whether the company's suppliers are local, national or international.

Although 20 supply chains were originally selected to take part in the study due to time constraints and difficulties in gaining access to companies only 10 of these were identified and studied.

The companies studied were either identified by Bristol University, members of the steering group or by following up leads from various contacts. They included five dairy, three pork, one fresh produce and one convenience food manufacturer. While some of the companies were part of the same chain the factories selected either manufactured different products, had different processes in place or were of a different size therefore no two factories were the same.

Table 1: Information on companies studied

	Product(s) Produced	**Years in operation**	**No of staff**	**Size of site (acres)**	**Suppliers**
Dairy 1	Yoghurt	1-20	201-400	10-20	Local
Dairy 2	Yoghurt	21-40	400+	10-20	Local
Dairy 3	Liquid Milk	21-40	101-200	10-20	Local
Diary 4	Butter & Spreads	61+	1-50	10-20	Local
Dairy 5	Cheese & Powdered Milk	21-40	51-100	6-10	Local
Meat 1	Pork Products, Sliced Meats, Sausages, Black Pudding, Convenience Meals	61+	400+	21+	Local, National, International
Meat 2	Pork Products	1-20	201-400	10-20	Local, National
Meat 3	Pork Products	21-40	201-400	6-10	Local
Fresh Produce	Salad Produce	1-20	201-400	<5	Local, National, International
Convenience food	Pies	<1	1-50	<5	Local

WP3 – Data Collection Phase –
(i) Value Stream Mapping of food manufacturing supply chain, focusing on refrigeration usage.
(ii) Semi-structured interviews with key respondents from each organisation to identify key issues and their underpinning factors.

Data collection was carried out using two methods. The first was value stream mapping of the food manufacturing supply chain and the second was semi structured interviews with key respondents from each organisation to identify key issues.

Value stream mapping was carried out based on the methods used by Rother and Shook (2003) in Learning to see, Value Stream Mapping to create value and eliminate muda (waste).

Selected organisations were contacted by email or telephone describing the aims and objectives of the project. Once an interest had been shown in the project a date and time for an initial visit was agreed. Here the scope and objectives of the project were described in more detail and mapping tools to be used were discussed. This meeting also gave each company the opportunity to individually consider the potential benefits of the project and whether they were willing to go ahead and participate. All initial visits were carried out between March and May 2007.

Once agreement had been made from the companies wishing to participate, further visits were carried out between June and October 2007 to collect date using the Value Stream Mapping approach and semi structured interviews.

Value stream mapping was carried out whilst walking around the factory floor and talking to the key individuals in each department identified by the site manager as those with the most knowledge of each particular area.

The data collection started in the suppliers department and worked all the way through each of the manufacturing processes gathering information and data such as process cycle times and number of workers.

In order to convert the data obtained from walking around the site into a current state map an A4 size sheet of paper was taken and icons were drawn (appendix 1) representing each of the process steps and flow of materials. Customer, supplier and production control icons were added along with the truck and shipment icons to show deliveries from suppliers and deliveries to customers. To show information sent to and from customer control electronic and information flow icons were added.

It is important to indicate on a value stream map how each part of the process knows what to make for its next customer. The most common representation is the push system this is where a process produces something regardless of whether the next process down stream needs it. This is indicated using the push arrow icon. These were added to each of the diagrams where necessary.

The final part of a value stream map is the time line. This was created by drawing a line by each of the process boxes. This represented the production lead-time of one part through the whole of the process from raw material to shipment to customer

It is important to note that where more than one product group was manufactured in the same organisation the main product line in the factory was mapped. This was identified by the site managers.

Once process data had been collected for the value stream mapping more detailed information was required to complete the current state map. The focus here was on unstructured or semi structured interviews with representatives of whom the site managers had identified as being the most appropriate people to talk to. Here questions were designed in order to gain more information about each of the companies concerning their suppliers, customers, processes for example:

- Customer demand
- Ordering frequency
- Shipping frequency
- Forecast frequency

- Production batches

These questions were open-ended and were designed to allow a greater understanding of each of the companies and the way in which each of the processes played a part in the manufacturing of a product. These interviews also allowed a rapport to develop between the researcher and the interviewee therefore allowing the researcher to probe areas suggested by the respondent's answers. This information was vital in understanding what the company does and how they achieve this.

WP4 – Data Analysis; Analysis to identify key areas of waste which contribute to unnecessary refrigeration usage and solutions to their negation/reduction.

This section will discuss the supply chain and manufacturing processes within each of the 10 companies visited between March and October 2007 it will also examine how possible energy savings maybe made through a reduction of refrigeration usage.

Dairy Processors

The five dairy companies visited produce a variety of products including yoghurt, milk, butter and spreads, cheese and powdered milk. The sizes of these companies varied greatly however the processing principles in the first stages of processing are quite similar.

Raw milk is collected from farms in and around the areas of the sites. On arrival, the raw milk is tested for temperature, taste, added water, acidity and antibiotics. Once the load passes these receiving tests it is pumped into large storage silos. All raw milk within these silos is processed within 72 hours of receipt at the plants.

Yoghurt

Dairies 1 & 2 both manufacture yoghurt and have the same processing steps however they differ in size and produce a different variety of products. A diagram of the processes throughout the yoghurt factories can be seen in Appendix 2.

Upon receipt raw milk is standardized this involves reducing the fat content and increasing the total solids, the fat content is then reduced by using centrifugation to separate the fat from the milk. The solid content of the milk can then be increased further by evaporating off some of the water or by adding milk powder. After the solid composition has been modified to the required consistency the milk is pasteurized. This involves heating the milk to 50°c for 15 seconds to destroy the microorganisms in the milk that may interfere with the controlled fermentation. The pasteurised milk is then homogenised at 180°c to break up the fat globules in the milk. This process produces a smoother and creamier end product.

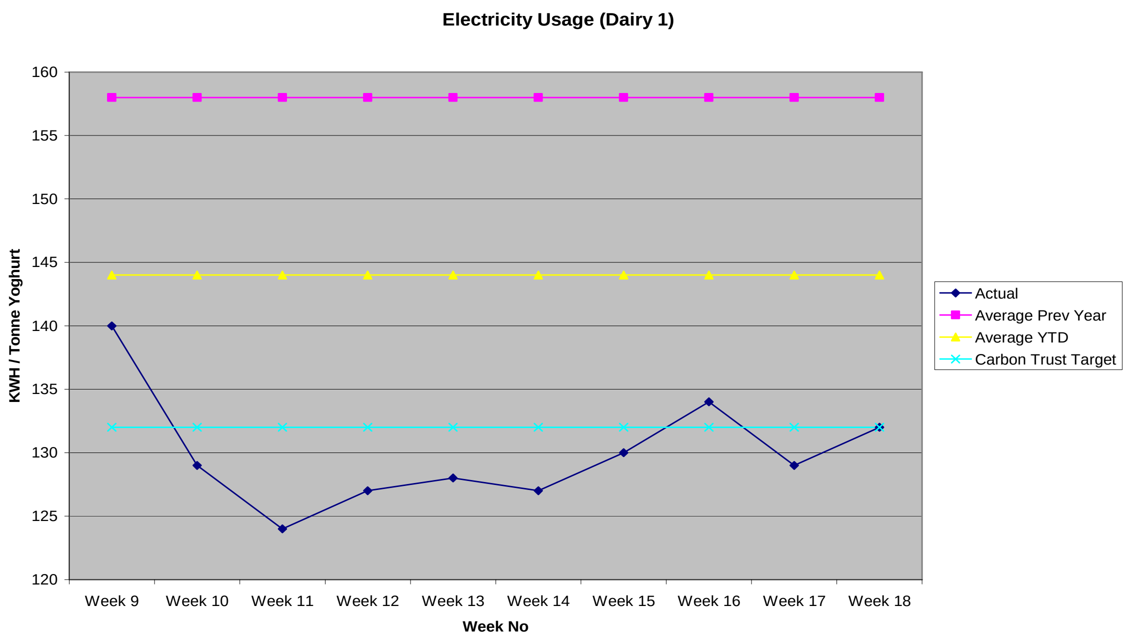
The processed milk is transferred to an incubation tank where the temperature is reduced to 41°c. Here two different methods are used to reduce the temperature. First is a cooling jacket which takes approx 8 hours to cool the yoghurt down to the required temperature and the second is central agitation which takes around 4 hours. Once the yoghurt has been cooled to the acquired temperature of 41°c culture is added accordingly. This whole process takes around 8-10 hours depending on the yoghurt type.

Mixture is then transferred to smaller holding tanks and fruit and flavourings are added as required. The holding tanks are connected to the filling machines and the mixture is pumped into pots, sealed and date stamped. At this stage the yoghurt is still around 20-30°c however in order for the product to be despatched the required temperature is <5°c. This proves problematic for the two sites since the yoghurts are packed into cardboard trays and placed onto a pallet with restricted access for air movement. Chiller boxes are used to reduce the temperature however they are not energy efficient and they take too long to cool the yoghurt. The sites also use rapid blast systems which hold around 10 pallets, these are set between -3°c to -6°c. However the pallets of yoghurts still take 2 hours to meet the required temperature of <5°c.

Table 2 shows a summary of the approximate temperatures of the yoghurt mixture throughout the processes within the factories.

Approximate temperatures throughout the different stages of yoghurt processing				
Initial	After Processing	After incubation	Filling	Despatch
6°c	180°c	41°c	20-30°c	<5°c

Graph 1 shows the electricity usage for the smaller of the two dairies. Although the energy usage for this year to date is lower than the previous year it is still higher than the carbon trust target which is set at x% below the previous years average usage per tonne of product produce.

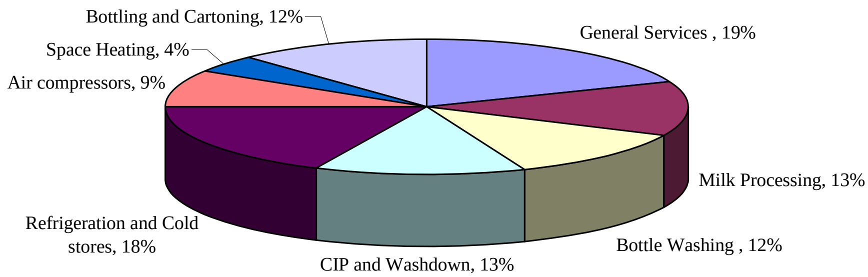


Liquid Milk

Dairy three is a liquid milk processing plant; the processing steps for this can be seen in appendix 3.

Fig 1 shows the energy cost breakdown in liquid milk dairies. Apart from general services, refrigeration and cold stores are the second highest user of energy. This can be attributed to the high processing temperatures of the milk and the level of cooling needed to achieve the appropriate despatch temperature

Fig1: Energy cost breakdown in liquid milk dairies



Source: The Carbon Trust

Upon receipt, raw milk is pasteurized at 30°c for 25 seconds to kill any 'pathogenic' bacteria which may be present. The cream and skim portions of the milk are separated by a large centrifuge that spins around 2,000 rotations per minute. The different types of milk are then standardized by blending the components (skim milk, raw milk, cream) to yield the desired end products. The next stage is homogenization to prevent the cream portion from rising to the top of the milk bottle. The homogenizer forces the milk under high pressure through a valve that breaks up the butterfat globules to such small sizes so they will not coalesce.

Processed milk is then pumped into appropriate bottles/cartons, sealed, date stamped and packed into trolleys which are transferred to the cold storage area. Milk is bottled automatically however the cold storage area is situated on a raised platform and therefore the use of a conveyor is needed to transport the milk up to the desired area. Milk is stored here for around 24-48 hours ready for picking for despatch to the appropriate customers.

Due to unpredictable orders from customers, the milk manufacturing site hold a buffer stock which varies with each individual product and is topped up once an order is received. However, this means that more stock is kept in the storage area and has to be maintained at the required temperature for longer.

Table 3 shows a summary of the approximate temperatures of liquid milk throughout the processes within the factory.

Approximate temperatures throughout the different stages of liquid milk processing		
Initial	Processing	Despatch
6°c	70°c	<5°c

Butter and Spreads

Dairy 4 a butter and spread factory, manufacture to order and process one product one day and a different one the next. Products are tested on a daily basis with butter being tested every half hour and spread tested in a batch process. Here they are tested for flavour and texture.

Butter production involves cooling and churning prior to packaging therefore substantial amounts of energy are used. The current state map for this factory can be seen in Appendix 4.

Raw milk is firstly separated into skim and cream. The skim is then pasteurized and cooled before being pumped into storage where it is either condensed through an evaporator, sold to outside companies or used in animal feed.

The cream is pasteurized at a temperature of 72°c for an hour and a half to destroy enzymes and micro-organisms that would impair the keeping quality of the butter. The cream then enters the cream storage tanks where it is held for around 12-15 hours to age. This is then pumped into a churn; here the cream is violently agitated to break down fat globules causing the fat to coagulate into butter grains. The result is butter grains and buttermilk. The buttermilk is drained from the butter and despatched to outside sources.

The site manufactures different types of products therefore different processes are in place depending on the end product. On the day of data collection, the site was making specially selected butter for the company’s main customer.

Here butter grains are pumped into 25kg lined boxes sealed, frozen and stored 25 miles away. The bulk butter is then melted down and re churned to improve the texture. This method is used for specially selected butter for the company's main customer. The butter is then re packed into plastic containers, size depending on the customer's requirements, sealed and date stamped. Temperature of the butter at this stage is around 12-15oc. It is then transported to the storage area ready for picking and is stored between 0-5°c.

Table 4 shows a summary of the approximate temperatures of butter throughout the processes within the factory.

Approximate temperatures throughout the different stages of Butter processing				
Initial	After Pasteurisation	Storage	Packing	Despatch / Storage
6°c	72°c	12-15 hours	12-15°c	<5°c

Cheese and Powdered milk

Dairy five is a powdered milk and cheese processing factory. A process diagram can be viewed in appendix 5. Here raw milk is separated to make skim milk and cream. The skim is then separated and pasteurized to make skim milk and the cream is pasteurized to make whole milk. These are then standardized to the required ratios.

For powdered milk the standardized milk is placed into a evaporator where water is removed until it becomes 48% solids, it is then transferred into a homogenizer and then into a spray dryer were the condensed milk is sprayed as a fine mist into a heat chamber kept at 100°c. As the milk droplets fall the swirling air quickly removes the water out of the droplets of milk until all that's left is a small particle of milk powder.

Powder drying at the site is a 24/7 operation carried out automatically. The site has two drying streams and two stork evaporators feeding two spray driers. A vast amount of money is spent here on electricity for hot air and for fuel. The site is currently looking at ways on how they can improve on this.

For cheese preparation, separation of the curd and whey is carried out on a night shift so that by morning the solids (curd and whey) are ready for processing. Curd is treated in an alfamatic machine and is vacuum packed into a 20kg bag this is then heat sealed, weighed, date labeled and boxed. The boxes are then placed into the rapid chill at 4°c for 24 hours or over the weekend. A pallet holds 40 boxes however only half this amount is placed on them to allow for quicker cooling. After the cheese has been chilled, it is then removed from the boxes (which are needed to keep the shape) and left to mature. Cheese is then re-packed in line with the customers requirements, which could be in bulk packages for caterers, smaller packs for retailers or grated for both. The site had limited storage for the powder milk and cheese and therefore the majority of it is stored in outside storage at a logistics company.

Summary

The information above has shown that the dairy industry is particularly electricity demanding. This is due to the thermal requirements of its many processes such as pasteurization, homogenization and spray drying. The main problems in the dairy industry are:

- Achieving and maintaining low temperatures for despatch
- Storage
- Design and layout of sites

All of the sites visited find it difficult to achieve the required temperature for despatch in a short period of time furthermore storage was a major issue in the cheese, powdered milk and butter, spread sites since these products are manufactured in bulk, and cheese for example requires times to mature.

The majority of the sites had little space for further developments and the layout of the processing lines could be improved dramatically with little investment.

Pork Processors

The meat companies studied all manufactured pork products. The factories varied greatly in size and can slaughter from 1000 to 1700 pigs a day each. Livestock is received at various times throughout the day and they are normally unloaded within 30 minutes arrival at the lairage. The slaughtering process takes approximately 45 minutes however the chilling of the meat, de boning, cutting/slicing and packing takes much longer.

Processes throughout the abattoir can be seen in Appendix 6. Firstly, the pigs must be rendered unconscious, to do this two different methods are used. The first by an electric shock to the head which stuns the pig within 15 seconds. The second is Carbon Dioxide (Co2) this method takes no longer than 60 seconds. Two of the sites visited used stunning whereas the larger site of the three used Co2. Once the pigs are rendered unconscious, they are hung upside down by their hind legs or hips on a processing line and the main arteries and veins in the pig's throat are severed causing death through exsanguination. The method by which the pigs are made unconscious and are hung on the processing line often determines the quality of the final product.

Carcasses are placed into a steam tunnel/scald tank which has a temperature of around 80°c to soften the skin. They are transferred into a de hair unit, a singer for 5-10 sec at a temperature of around 700°c and they are then scraped and polished to remove any final hairs.

They are opened up along the breastbone to allow removal of the organs which are kept in correlation with the carcass for inspection. The backbone is split centrally down to the head to enable the complete removal of the spinal cord and the carcasses are inspected for tumors or anything unordinary by meat inspectors. If any problems are discovered, they are detained and inspected further. Carcasses are then weighed, stamped to acknowledge they have passed inspection and placed into the deep chill where they are stored between 0-5°c for up to 16 hours overnight depending on the sites specifications. This length of time is needed so that the meat is at an ideal temperature to be able to be cut and de boned, any warmer and the meat would be too tough.

Once the carcasses have been stored for the required amount of time, they are then broken down into subprimals and primals for boxed meat or processed into bacon, cured meats, chops etc. Processing for this varies on the product however; thousands of cuts of pork, bacon, legs etc can be completed within the day.

Processed meats for example are cooked at a temperature of 80°c and are then placed into the blast chiller at 5°c for 16 hours. They are sliced, packed and date stamped and moved to the cold storage area for approximately 2-3 days at a temperature of <5° until they are ready for despatch. Depending on the site, deliveries are made either directly to the customer or to a logistics company who receive customer's orders and pick goods accordingly.

One of the sites studied has a major problem with refrigeration due to the amount of machinery used in each of the individual processes. They try to keep rooms chilled to 5°c or below however in reality the temperature is approximately 9-10°c. Also due to the design of the site some chilled rooms are used as a thoroughfare therefore doors are left open.

One of the sites also buys in meat from within the group since it is an open market. For example, chicken and corned beef are bought from sister sites and processed into sliced meats. The company also has two sites in Thailand whom they buy products from. These arrive frozen in bulk and the site individually packs them for stores. These products can be made in the UK but the cost of labour is less abroad therefore they are processed abroad and transported in refrigerated vehicles to the UK.

Seasonal ranges are also processed at some of the sites for example pigs and blankets for Christmas. Production of these starts in September and extra staff are employed to meet customer's requirements. For one particular product, the customer has not yet designed labels for the product therefore the product will go to the logistics company for storage without. Once the labels have been designed, they will either be transported back to the company to label or if the logistics company have the correct machinery, they will be labelled there.

Table 5 shows a summary of the approximate temperatures of pork throughout the processes within the factory.

Approximate temperatures throughout the different stages of pork processing				
Initial	After cleaning	Chill	Cutting.& de boning	Despatch
37°c	67-80°c	-4 to 5°c	5-10°c	<5°c

Summary

The main energy usage in the pork factories visited are:

- Chilling of carcasses
- Maintaining temperatures throughout the factory
- Transportation

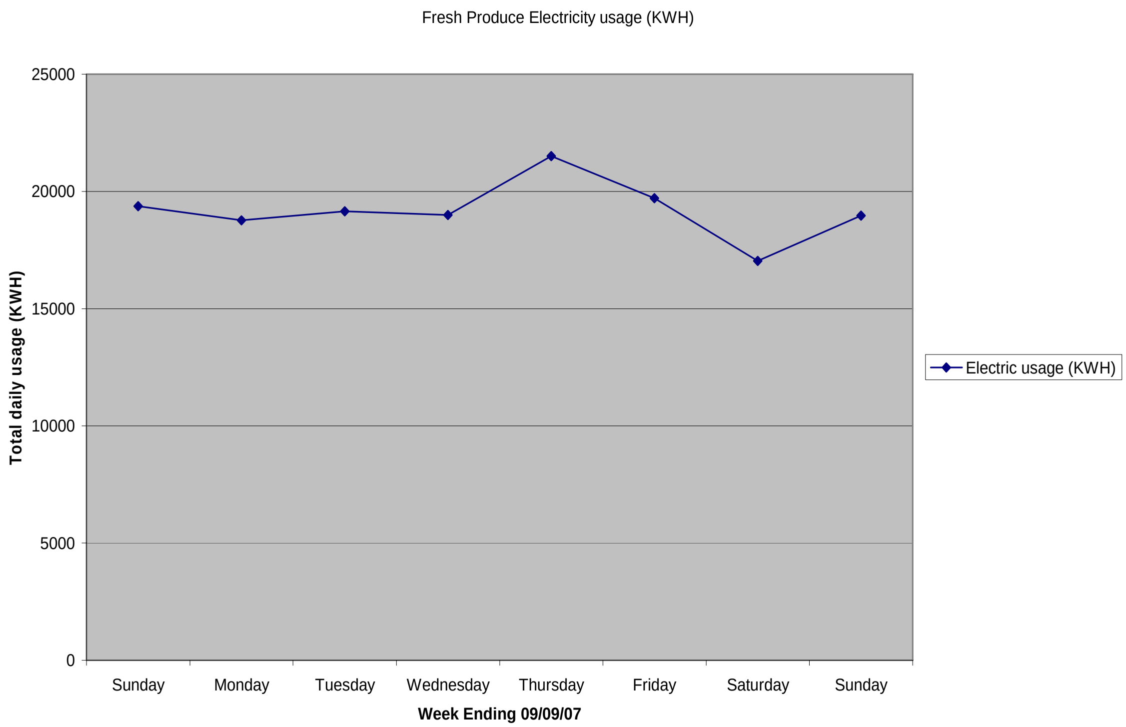
Carcasses need to be chilled for 16 hours so that the meat is at a suitable temperature to be cut and de boned. Temperatures throughout the factories varied greatly due to the design and layout. In some sites, although rooms are chilled to 5°c the actual temperature is much higher due to machinery used in the production processes and rooms being used as a thoroughfare. Transportation is also another main energy user with goods being transported to and from logistics and between sister sites locally, nationally and internationally.

Fresh Produce Processors

The company visited is a fresh produce manufacturer producing salad produce for supermarkets, caterers, food chains and retailers. They use mostly home grown UK leaf from May to October however come October the majority of supplies and more exotic leaves are imported from Spain, France and Italy except from the more common fresh produce which can still be grown locally. Deliveries from Spain take around 3-7 days therefore the site hold a 3-day buffer stock incase problems arise with suppliers.

The site receives forecasts from supermarkets early in the morning with confirmed orders from lunchtime onwards for delivery that day. Orders tend to increase on a Thursday and

Friday ready for a weekend and in particularly throughout the summer months. Graph 2 shows the electrical usage (KWH) for week ending 09/09/07 at the factory. A peak in electric usage due to an increase in orders can be seen on a Thursday and Friday and a decrease on Saturday rising again on a Sunday for orders throughout the week.



Various temperatures are in operation throughout the factory and these range from <5 °c to ambient. The intake and chilled area is kept below 5°c whereas the preparation area is kept from 5°c to ambient temperature to allow workers to be able to work comfortably.

The wash process of salad produce starts with hand preparation of the leaf ingredients; these are washed in a special two-stage process, which combines water and air to remove any dirt from the raw material. The second stage is to wash the leaves in a water solution containing chlorine. From the wash process the ingredients pass into a special high car area where the finished product is packed. It is then weighed, boxed, labelled, placed onto a pallet, and transferred to the storage area where it is held for up to 8 hours below 3°c.

Once the salad cut surface is exposed to air, the cut surfaces will brown or pink by enzyme action therefore it is important that the factory temperature, wash processes and packaging methods are designed to reduce the effect of the enzyme action.

The graph below shows the temperatures at the site for the raw materials corridor 1 &2 and raw materials 1 at 10am on the 9th September 2007 to 6pm on the 10th September 2007. Temperatures are monitored every 20 minutes and the site tries to maintain these at <5°c however the graph shows that the temperatures vary throughout the day with the highest temperatures being in the raw materials corridor 2. These peaks however can be correlated to when the system goes into defrost and the other variations in temperature are when the sites receive and despatch goods.

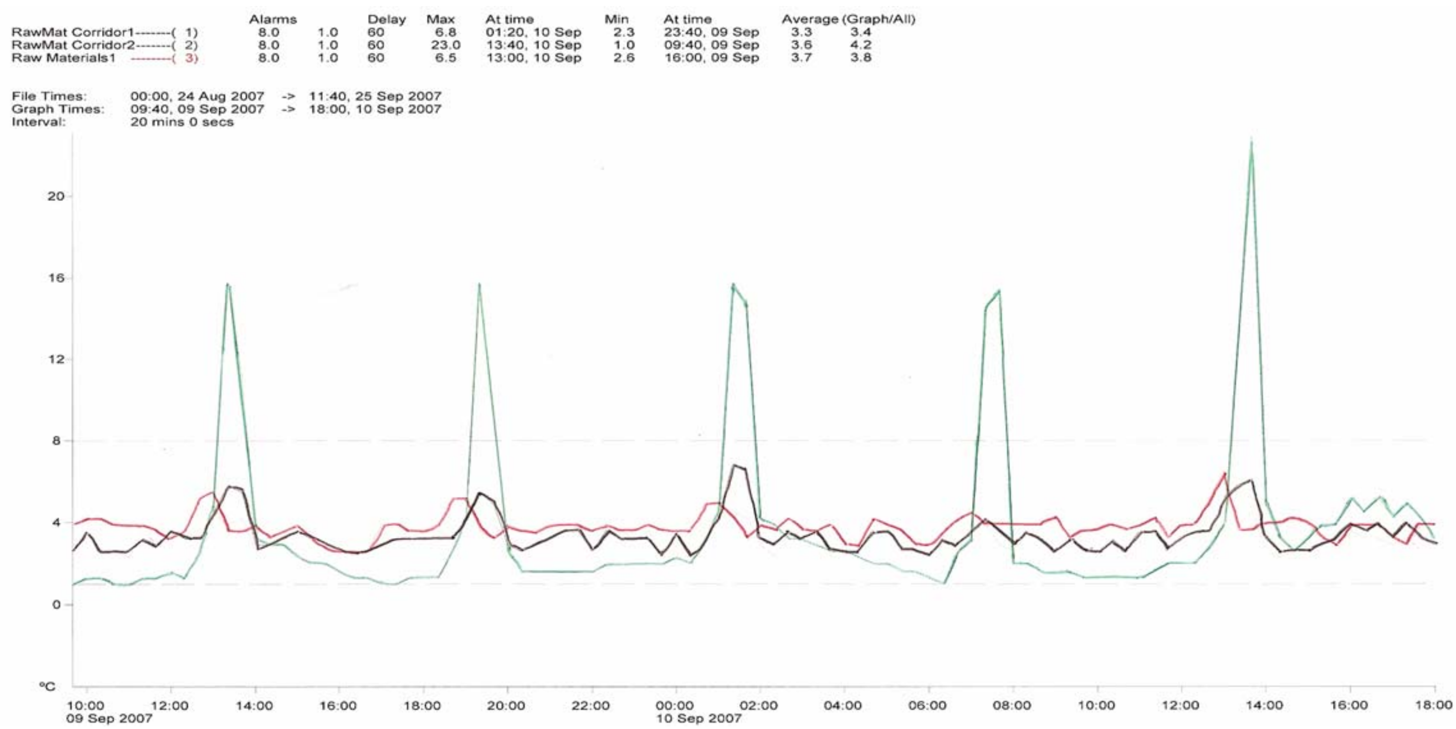


Table 6 shows a summary of the approximate temperatures of fresh produce throughout the processes within the factory.

Approximate temperatures throughout the different stages of fresh produce processing			
Initial	Preparation	Pack	Despatch
<5°c	<8°c	<5°c	<3°c

Summary

Maintaining low temperatures throughout the factory is a major problem for fresh produce manufacturers since the temperatures can have a great affect on the produce. This site monitors temperatures and tries to maintain them however they are built on an existing factory layout and therefore they have to try and utilize the space they have as best as they can.

Convenience Food Processors

This small factory is relatively new and on the visiting date, it had only been situated in a new premise for 5 months. The products produced are a variety of pies, peas and mash. The company receives meat and vegetable deliveries daily and dairy twice a week.

The companies chilling areas are situated at the back of the factory next to the delivery and despatch areas. Here there is a raw materials freezer, raw materials fridge, finished goods freezer and works in progress fridge. This area leads into the preparation room where all ingredients which do not need refrigerating are stored for example tinned produce, herbs etc.

The process steps can be viewed in appendix 8. Here mixture is prepared according to the recipe and taken to the boiling pans situated in the main part of the factory. These large pans are used to cook the mixture to the required temperature. Once the mixture has be cooked it is cooled from around 75-80°c to below 10°c and kept in the works in progress fridge below 5ºc overnight ready for use for the next day. All pastry for the pies is made by hand and stored in the works in progress fridge overnight. Pastry is rolled out by hand, cut to the required size and placed into pie tins. A machine compresses the pastry down and flour paste is applied to the top of the pastry. The pies are hand filled, a lid is placed on top and sealed. The remains of the lid are trimmed from the pie, the edges pressed down and an egg wash applied. Pies are then placed into an oven which holds around 730 pies for 30 minutes at 207°c here they are placed onto a rotating pallet for even heat distribution.

In the high care end of the factory pies are taken from the oven and placed in front of two ambient temperature fans which run on 1.7kw for around 20 minutes to lower the temperature which at this stage is normally 75-80°c. Pies are then placed into the rapid blast chillers to a temperature of -6°c. The blast chillers have openings at either end so that products can be placed in one end and removed from the other.

Once cooled, pies are placed into the pie holding fridge where they are date coded and packed into one of the three types of packaging. Once packed the pies go through a metal detector and then into the despatch area which is kept at <5°c.

Summary

The main energy used at this site is in the cooling of the pies since this takes around 4-5 hours. The site is also built on an existing layout and although space has been utilized, many problems occur. For example, the ovens are situated next to the chilled area and ambient temperature fans therefore when the oven doors open heat escapes causing the temperature to fluctuate. The site however does have plans however to build a divide with curtains between the two rooms to try to control the temperature.

Key areas of wastage

The following areas of wastage have been identified:

- Inappropriate plant layout
  - New machinery added where space is available. For example, the milk processing plant had a shrink wrapper in the cold storage area and the pie processing plant had an oven next to the chilled area.

- Poor information flow
  - Customers orders are often unpredictable and unreliable therefore many of the sites hold a buffer stock.

- Badly utilised equipment
  - Inappropriate quantities of storage in chilling rooms

- Technical errors with machinery
  - Inappropriate maintenance practices

- Repetitive handling and moving
  - Goods moved between various rooms / sites. Rooms used as thoroughfares.

- Inconsistent product quality
  - Customers specifications are not met therefore products are rejected. For example damaged stock due to poor processing lines.

- Inconsistency of processes
  - Due to staff/product changeovers

- Transportation
  - To and from logistics, customers, sister sites and suppliers.

Possible Solutions

- Energy monitoring
- Fit sub metering equipment

- Maintenance practices
- To improve machine errors

- Re development of the processing lines
- To avoid unnecessary movement of goods

- Space utilisation
- Improve plant layout and processing lines

- Streamline Supply chains
- Improve information flow

- Utilise the opportunity for heat recovery
- None of the sites studied recovered heat

- Improve product handling
- Reduce defective stock and wastage

- Fit door strip curtains or automatic doors
- Minimise changes in temperature

Conclusion

This project has highlighted the complexity of the supply chains studied and has uncovered a number of opportunities to improve efficiencies. To reach the target of 20%

reduction in CO_2 emissions by 2010 there needs to be a change in attitudes regarding energy efficiency and an investment in alternative and new technologies

Throughout all of the sites, multiple heating and cooling processes throughout production are present thus resulting in an increase in energy consumption. Furthermore, many of the sites are built on existing factory layouts where space is limited and in some cases not utilized effectively.

Repetitive handling and movement of goods is present due to disorganized processing lines and supply chains resulting in inconsistent product quality. Therefore, a need to re develop and streamline the processing lines and supply chains is present to improve product handling, reduce stock and streamline frequency of collections and deliveries.

Transportation is also another main energy user with some companies obtaining goods from overseas where although the labour and the cost to make the produce is much less the effect on the environment/carbon footprint is vast.

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Appendix 1

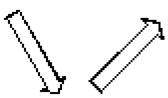
Value Stream Mapping Icons

Outside source

This icon represents the Supplier when placed in the upper right side of a diagram and is usually the starting point for material flow. The customer is represented when placed in the lower right, the usual end point for material flow.

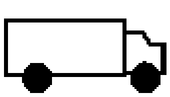
Manufacturing Process
This icon is a process, operation, machine or department, through which material flows.

Shipments
This icon represents movement of raw materials from suppliers to the Receiving dock/s of the factory. Or the movement of finished goods from the Shipping dock/s of the factory to the customers



Movement of Production
This icon represents the pushing of material from one process to the next process. Push means that a process produces something regardless of the immediate needs of the downstream process

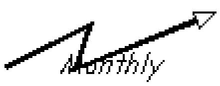
External Shipment
Shipments from suppliers or to customers using external transport.



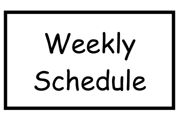
Production Control
This box represents a central production scheduling or control department, person or operation.

Manual Info
A straight, thin arrow shows general flow of information from memos, reports, or conversation.

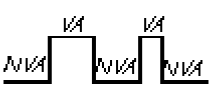
Electronic info
This arrow represents electronic flow such as electronic data interchange (EDI), the Internet, Intranets, LANs (local area network), WANs (wide area network).



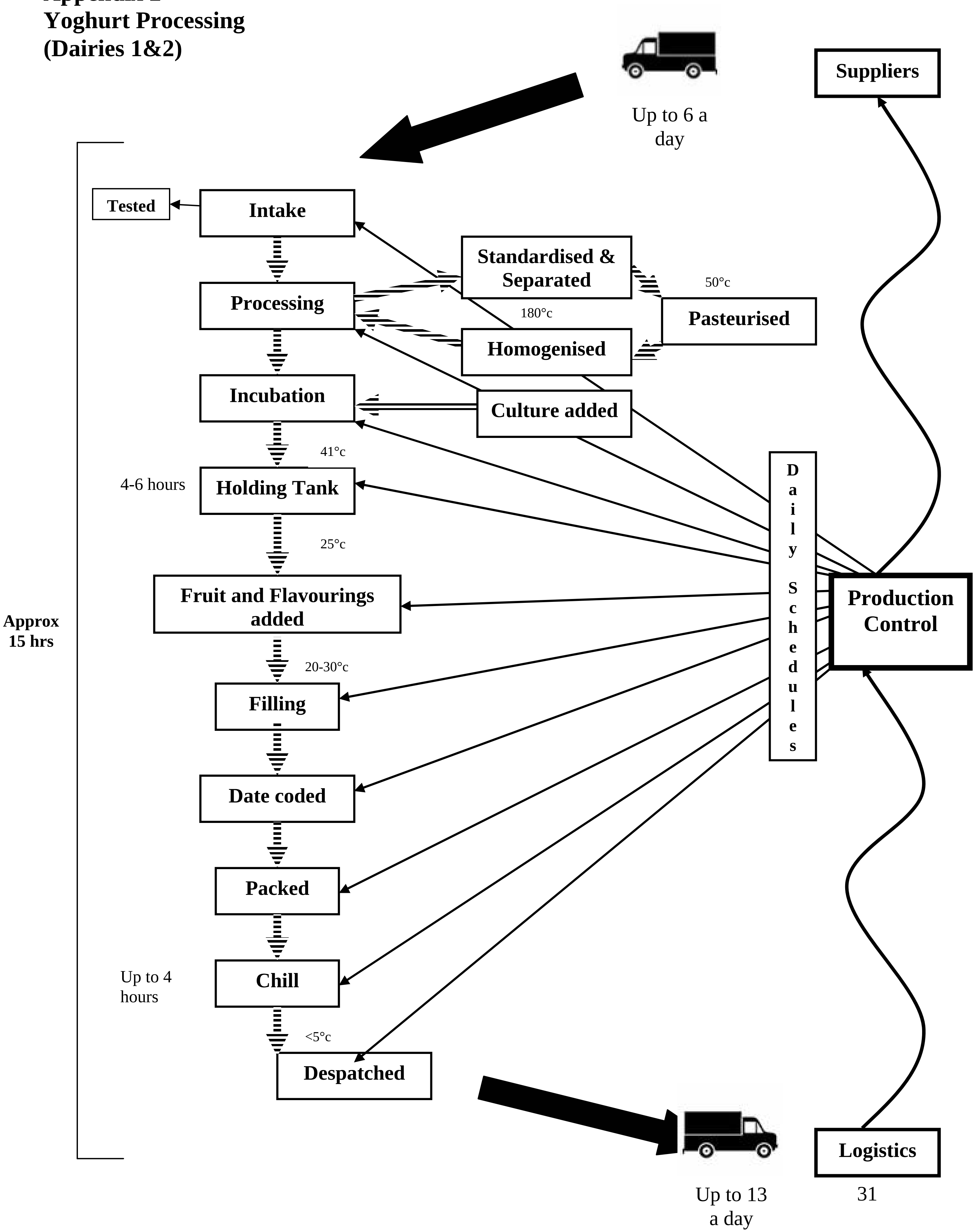
Information Box
Provides additional information



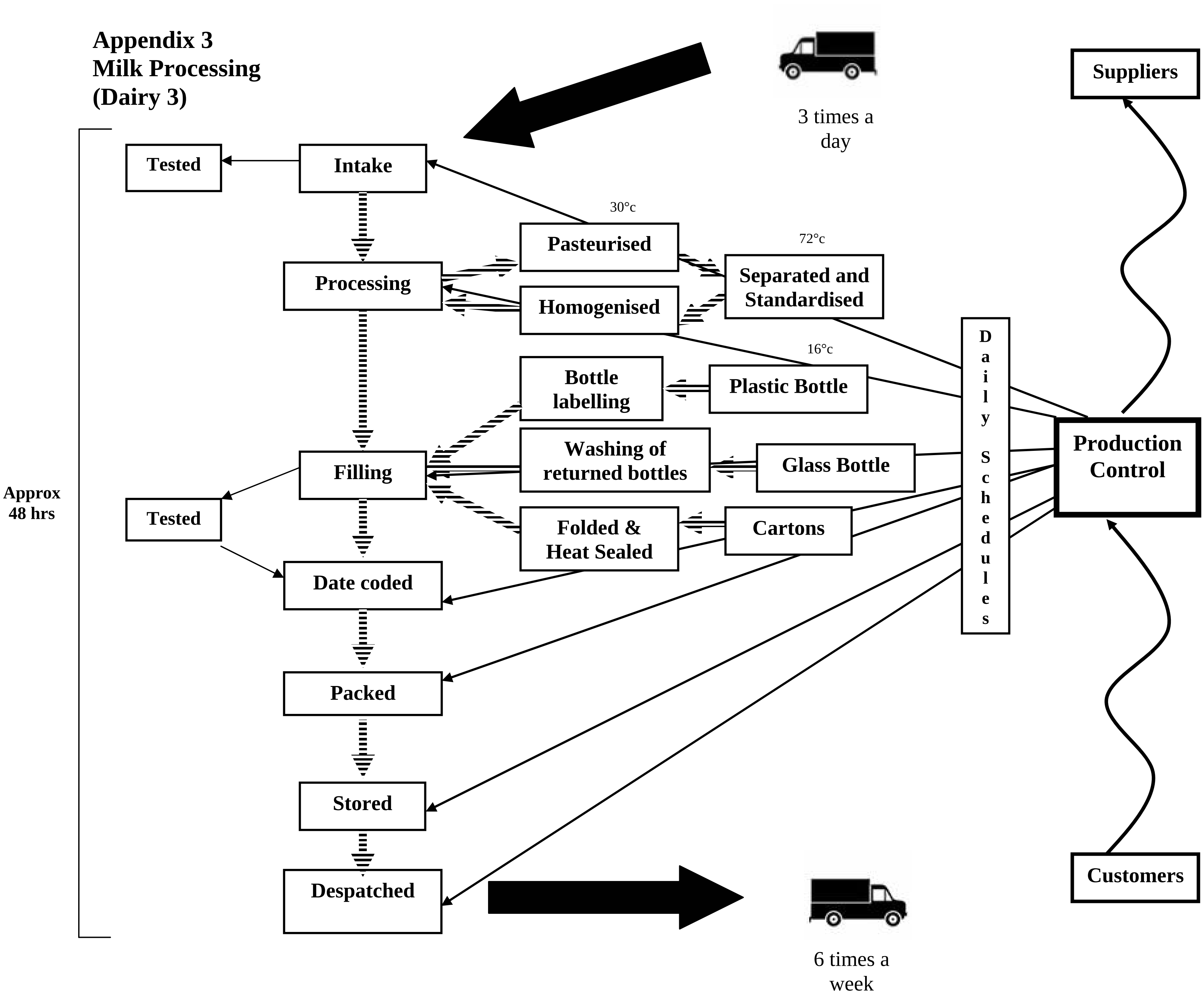
Timeline
The timeline shows value added times (Cycle Times) and non-value added (wait) times. Use this to calculate Lead Time and Total Cycle Time.



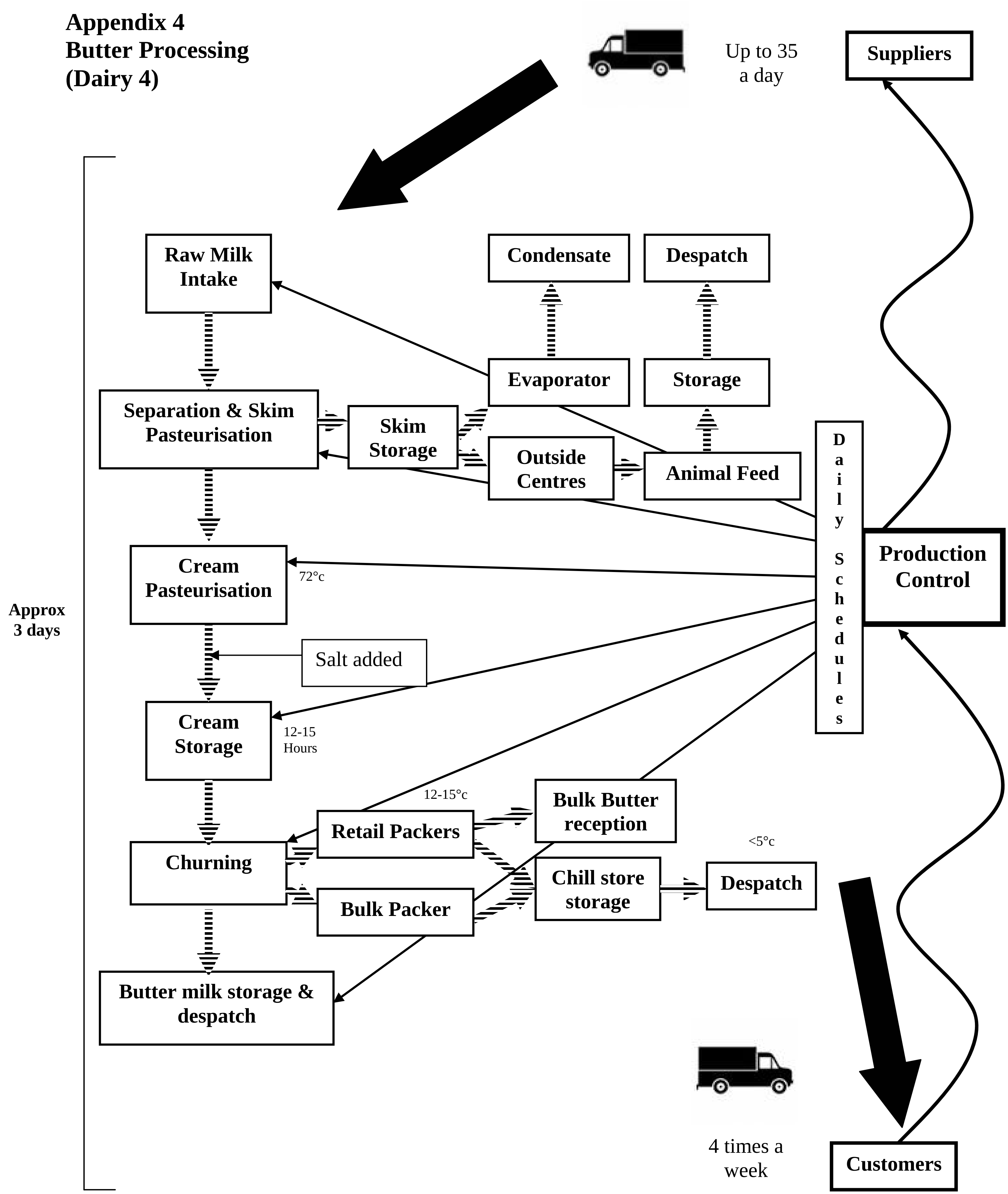
Appendix 2
Yoghurt Processing
(Dairies 1&2)



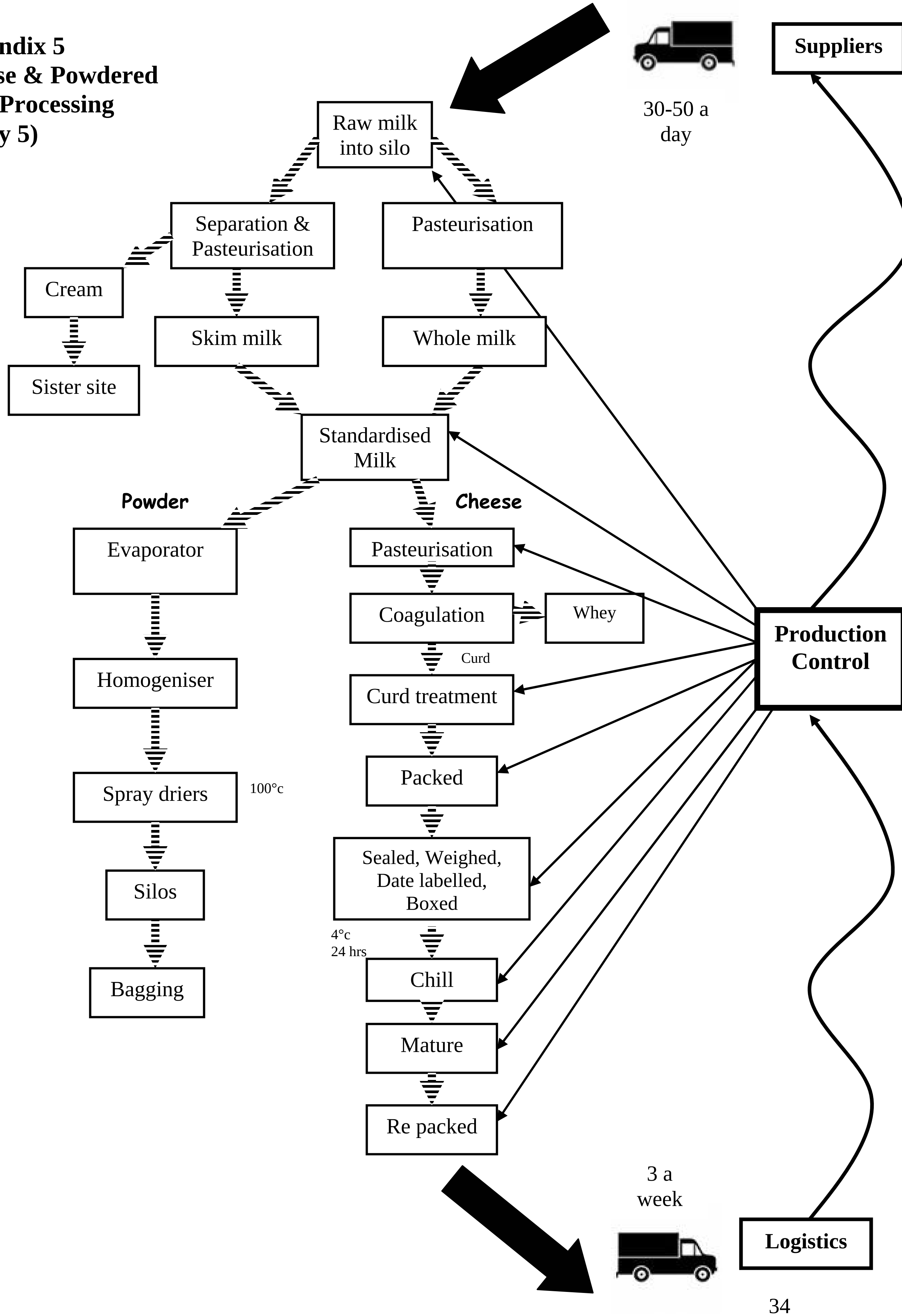
Appendix 3
Milk Processing
(Dairy 3)



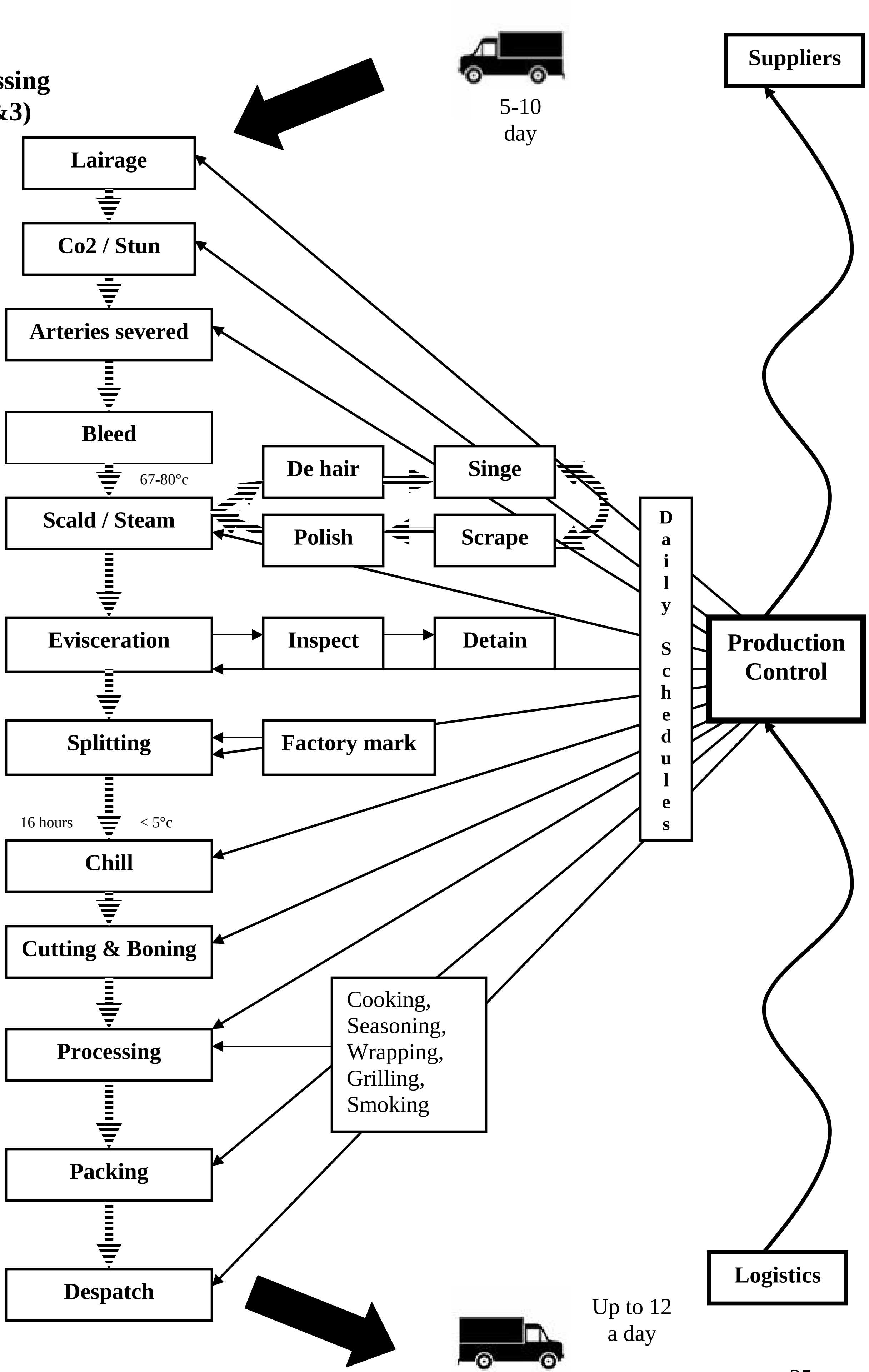
Appendix 4
Butter Processing
(Dairy 4)



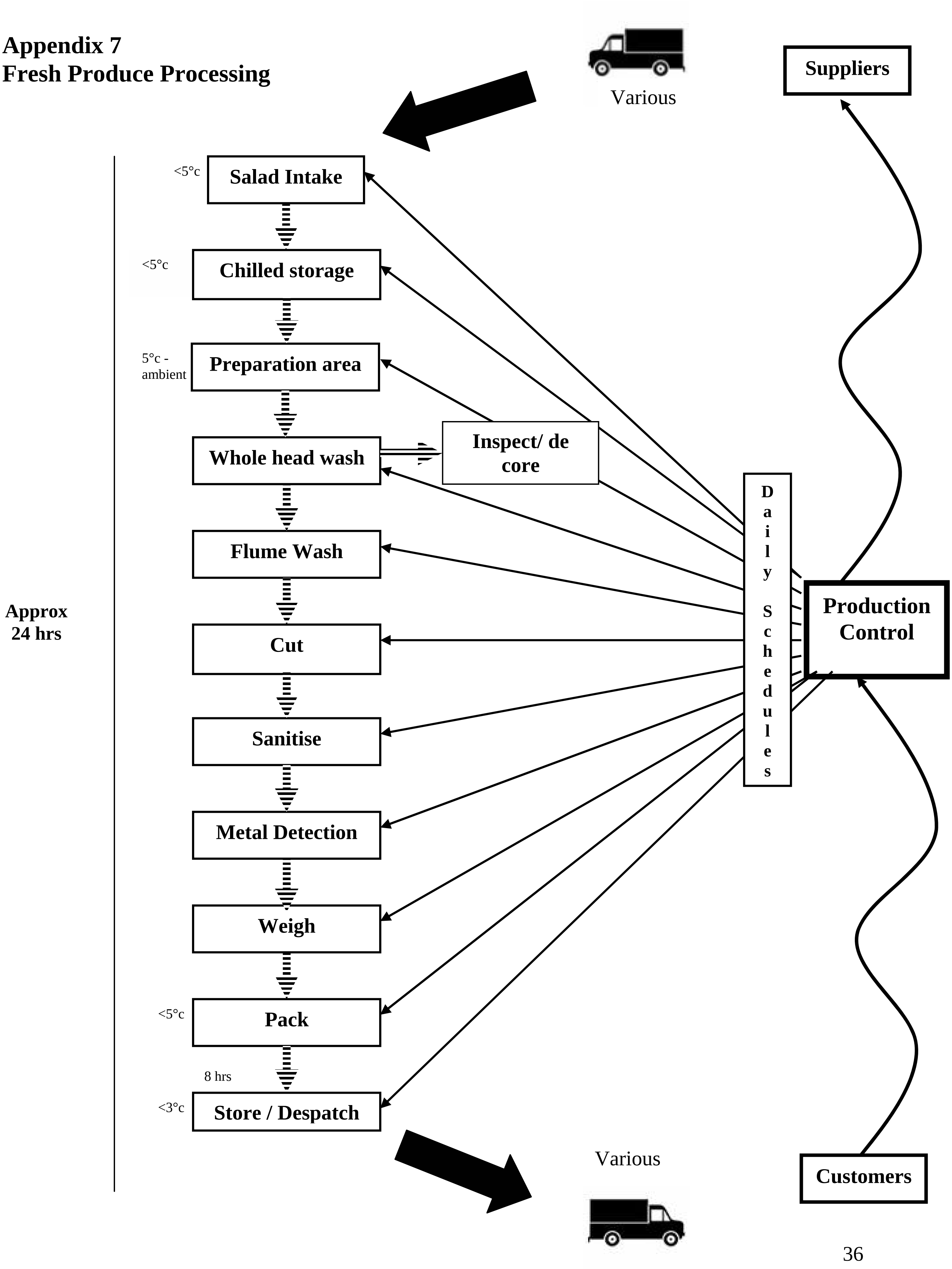
Appendix 5
Cheese & Powdered Milk Processing (Dairy 5)



Appendix 6
Pork Processing
(Meat 1, 2 &3)



Appendix 7
Fresh Produce Processing



Appendix 8
Pie Processing