REDUCING WASTE OF CHOCOLATE SPREAD GENERATED DURING PRODUCTION AT BRINKERS FOOD B.V.

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Date: March 20, 2019

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Document Title:		Reducing waste of chocolate spread generated during production at Brinkers Food B.V.
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Acknowledgements

After an exciting and interesting half a year, it is time to finish my master thesis. This thesis is written in order to complete my master program Industrial Engineering and Management (track Production and Logistics Management) at the University of Twente.

I am really glad that I received the chance to write my master thesis at Brinkers Food. I would like to thank Jan-Arjen Kuipers for his guidance and great collaboration during this research. Furthermore, I would like to thank all employees at Brinkers for the interest they have shown in my graduation project and the input they gave me.

Moreover, I would like to thank my supervisors from the University of Twente, Peter Schuur and Hans Heerkens. Their useful feedback and support helped me to improve this thesis.

I wish you a lot of pleasure in reading my master thesis,

Daphne Voorwinden

Enschede, March 2019

Management Summary

Motivation

Brinkers is one of Europe's leading suppliers of chocolate spread and is located in Enschede. Brinkers must keep its production costs as low as possible and suspects that the costs of waste can be reduced. The management uses a KPI to measure the performance on the costs of waste. The upper limit of this KPI is set at €X for 2018 and it is already clear to management that this will be exceeded. In addition, the management still finds €X very high and they expect that this can be reduced. Therefore, there is a need for this research.

CRQ

The core problem is the discrepancy between the norm and reality, observed by the problem owner (Heerkens & Van Winden, 2012) and is formulated as:

'The total costs of waste during production are estimated to be higher than €X in 2018, which is the norm.'

Historical data and the experience of managers and production workers show that the waste of chocolate spread causes the largest costs. We therefore focus on the waste of chocolate spread in this research. The research question that arises from the core problem is:

How can the amount of waste of chocolate spread during production be reduced to lower the production costs?

At Brinkers it is not known which waste streams there are, how large they are and what causes them. We first have to investigate this, before we can propose a solution.

Method

To answer this central research question, we use the IST-SOLL method. After an extensive analysis of the current situation (IST), we create flow charts of the production process and aim to identify all waste streams in production. We keep the definition of waste and their categories as set by Ohno (1988) in mind to identify waste streams. As it is not relevant and it takes too much time to analyze all waste streams, we have to select the most important waste streams. We use the Impact matrix (Paris et al., 2007) and the experience of people from relevant departments at Brinkers to prioritize these waste streams based on their frequency and impact. We develop a method to measure these relevant waste streams. With the help of categories of causes as defined in the Lean Theory and experience of people at Brinkers, we aim to identify the causes for the largest waste stream. We use literature on waste management of other companies and brainstorming sessions to define solutions for the largest waste stream (SOLL).

Results

We have identified 21 waste streams and used the Impact Matrix (Paris et al., 2007) to identify six dominant waste streams, which are described in Table 1.

Waste stream	Definition
Waste stream 7	Jars that do not meet quality due to a product switch, exists of two parts: • 7a: jars in which the previous produced chocolate spread is visible in jars. • 7b: first jars that are not filled full enough after a product switch.
Waste stream 15	Extra weight, meaning more than stated on the label, is filled in jars.
Waste stream 16	Samples taken during production for quality control.
Waste stream 19	X
Waste stream 20	Cleaning tanks and pipes in between a product switch (first part: containing the previous produced recipe).
Waste stream 21	Cleaning tanks and pipes in between a product switch (second part: containing the recipe that is to be produced next).

TABLE 1: DESCRIPTION OF THE SIX DOMINANT WASTE STREAMS

We measured these waste streams during the month of December 2018. Based on a Pareto Chart (Morgan & Brenig-Jones, 2016) of the costs of waste per waste stream, we have identified the largest waste stream, namely the jars having a wrong color due to the color switch (waste stream 7a in Table 1). We used literature and carried out brainstorm sessions with relevant people to conduct a root cause analysis in which we aim to get all the causes of this waste stream on the table. We have found four improvements that meet the requirements set by Brinkers.

1. Design and implement static mixer in filling tubes.
2. Establish the norm on the required quality of products.
3. Correct waste registration in the ERP system.
4. Involve employees in the targets for waste set by the management.

We expect improvement 1 to directly contribute to reducing the costs of waste. (Re-) designing and testing of the filling tube with a static mixer will have to show this. Improvements 2 and 3 will contribute to the correct determination of the amount of waste. We expect improvement 2 to reduce the costs of waste, as within Brinkers there is a strong suspicion that too many jars are given to the foodbank. After setting the norm, Brinkers can check whether this is actually the case. Presumably by adjusting the norm, the quality if more in pace with consumer expectation and experience. However, by implementing improvement 3, the correct waste registration in Exact can in theory also lead to higher costs of waste. It is important that the management is aware of this. Improvements 3 and 4 together provide a better grip on the waste streams, so that immediate action can be taken if a waste stream suddenly becomes very large. The ball is in management's court now to implement the four improvements, with the use of the 11-weeks implementation plan in Table 2.

Actions	Actor	Weeks
• Hire an expert to design and test the filling tube with static mixer. • Create a manual on how and when to use the filling tube with static mixer. • Train employees in production how to use the new filling tube.	Plant Manager	4
• Develop cards on required quality for products. • Train employees in filling department how to use the quality cards.	Quality Manager	4
• Create reason codes in Exact for each waste stream (IT department). • Train employees in filling department on how to register waste in Exact.	Production Manager	2
• Create an outline of the meeting and organize the meetings.	Plant Manager	1

TABLE 2: IMPLEMENTATION PLAN

We already started with implementing the improvement actions. We made a prototype of the filling tube with static mixer, which can be seen in Figure 1. After testing we concluded that the filling tube with static mixer reduces the color stripes in de jars (Figure 2) and we therefore decided to implement this solution. In addition, we have made a start with registering waste streams in the ERP system. The IT department created reason codes for the waste streams in the ERP system and the filling department has received training on how to register the waste in the ERP system.

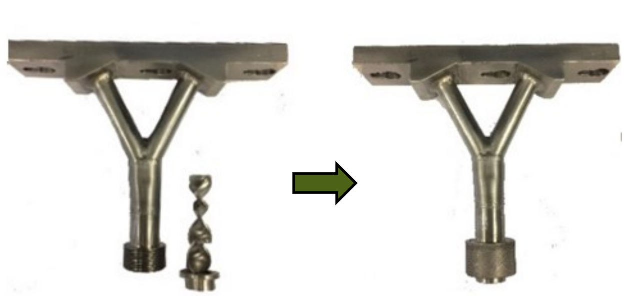


FIGURE 1: PROTOTYPE OF FILLING TUBE

FIGURE 2: LEFT: WITHOUT STATIC MIXER, RIGHT: WITH STATIC MIXER

Conclusion

We presume that the way in which we measured waste flows is sufficiently reliable to draw a good conclusion from. We advise Brinkers to follow the step-by-step plan in Table 2, so that the recommendations can be implemented correctly. In addition we advise Brinkers to do further research on other large waste streams we did not analyze in this research. We recommend starting with waste stream 20 and 21, namely the waste resulting from cleaning as we described in Table 1, which were the second largest waste streams from our measurements. Based on the measurements in this study, we expect that the registration of the six dominant waste streams explains the greater part of the costs of waste of €X. If it appears that still a too large part of the costs of waste cannot be explained, the Impact matrix we created can be used to see which waste streams can also be relevant to measure.

Samenvatting (Dutch)

Aanleiding

Brinkers is een fabrikant van chocoladepasta, gevestigd in Enschede. Brinkers moet zijn productiekosten zo laag mogelijk houden en vermoedt dat de kosten van afval verminderd kunnen worden. Het management hanteert een KPI om de performance van de kosten van afval te meten. De bovengrens van deze KPI is gezet op €X voor 2018 en het is voor het management al duidelijk dat dit overschreden gaat worden. Daarnaast vindt het management €X nog steeds erg hoog en zij verwachten dat dit verlaagd kan worden. Er is daarom een behoefte aan dit onderzoek.

CRQ

Het kernprobleem is een door de probleemhebber waargenomen discrepantie tussen de norm en de realiteit (Heerkens & Van Winden, 2012). Uit de probleemidentificatie kwam de volgende probleemstelling naar voren:

‘De totale kosten van gegenereerde afval tijdens de productie wordt geschat op meer dan €X in 2018, wat de norm is’.

Uit beschikbare data en ervaring van de medewerkers bij Brinkers blijkt dat het grootste deel van deze kosten bestaat uit kosten van afval van chocoladepasta, daarom focussen wij in dit onderzoek hierop. De onderzoeksvraag die uit de probleemstelling voortvloeit is:

Hoe kan de hoeveelheid afval van chocoladepasta die tijdens de productie ontstaat verminderd worden om zo de productiekosten te verlagen?

Binnen Brinkers is niet bekend welke afvalstromen er zijn, hoe groot deze zijn en waar ze door veroorzaakt worden. Dit moeten we eerst inzichtelijk maken voordat we kunnen denken aan een oplossing.

Methode

Om deze centrale onderzoeksvraag te beantwoorden, gebruiken wij de IST-SOLL methode. Na een uitgebreide analyse van de huidige situatie (IST), creëren wij flow charts en proberen we alle afvalstromen in de productie te identificeren. We houden de definitie van afval en de categoriën hiervan zoals beschreven bij Ohno (1988) in ons achterhoofd om te kans te minimaliseren dat wij een afvalstroom over het hoofd zien. Omdat het niet relevant is en het daarnaast teveel tijd kost om alle afvalstromen verder te onderzoeken, moeten we de belangrijkste afvalstromen selecteren. We gebruiken de Impact matrix (Paris et al., 2007) en de ervaring van mensen van relevante afdelingen bij Brinkers om deze afvalstromen te prioriteren. We hebben een methode ontwikkeld om deze relevante afvalstromen te meten. Met behulp van categorieën van oorzaken uit de Lean Theory en ervaring van mensen bij Brinkers willen we de oorzaken van de grootste afvalstroom boven tafel krijgen. We hebben literatuur over afval bij andere bedrijven en brainstormsessies gebruikt om oplossingen te definiëren voor de grootste afvalstroom (SOLL).

Resultaten

We hebben 21 afvalstromen geïdentificeerd, waarbij wij incidenten buiten beschouwing hebben gelaten. Met behulp van een Impact Matrix (Paris et al., 2007) hebben wij zes dominante afvalstromen gevonden, die worden beschreven in Tabel 1.

Afvalstroom	Beschrijving
Afvalstroom 7	Potten die door een productswitch niet aan de kwaliteit voldoen, bestaat uit twee delen: • 7a: pasta waarin de vorige geproduceerde chocoladepasta zichtbaar is in de potten. • 7b: eerste potten die gevuld worden en die niet vol genoeg gevuld zijn.
Afvalstroom 15	Extra gewicht (meer dan vermeld op het etiket), gevuld in de potten.
Afvalstroom 16	Monster potjes die tijdens productie genomen worden en getest door kwaliteitsafdeling.
Afvalstroom 19	X
Afvalstroom 20	Spoelpasta wat gebruikt wordt om de tanken en leidingen schoon te krijgen bij een productwissel (eerste deel: bevat het vorige geproduceerde recept).
Afvalstroom 21	Spoelpasta wat gebruikt wordt om de tanken en leidingen schoon te krijgen bij een productwissel (tweede deel: bevat het volgende recept dat moet worden geproduceerd).

TABEL 1: BESCHRIJVING VAN DE ZES DOMINANTE AFVALSTROMEN

We hebben deze afvalstromen gemeten in de maand december 2018. Op basis van een Pareto Chart (Morgan & Brenig-Jones, 2016) van de kosten van afval per afvalstroom hebben wij de grootste afvalstroom geïdentificeerd, de kleurovergang die zichtbaar is in potjes door een productovergang (afvalstroom 7a in Tabel 1). Met behulp van literatuur en brainstorm sessies met mensen hebben wij een root cause analysis uitgevoerd met als doel om alle oorzaken van deze afvalstromen boven tafel te krijgen. We hebben vier verbeteringen gevonden die voldoen aan de randvoorwaarden die Brinkers stelt.

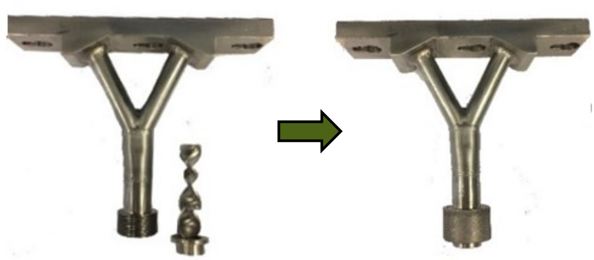
1. Het ontwerpen en toepassen van een vulkop met statische menger (Figuur 1).
2. Het vaststellen van de norm van kwaliteit van producten.
3. Het registreren van afvalstromen in het ERP systeem.
4. Het betrekken van de werknemers bij targets over afval die het management stelt.

We verwachten dat verbetering 1 direct bijdraagt aan het verminderen van de kosten van afval. Het ontwerpen, testen en eventueel herontwerpen van de vulkop zal dit moeten aantonen. Verbetering 2 en 3 zullen bijdragen aan het correct vaststellen van de hoeveelheid afval. Wij verwachten dat verbetering 2 tot minder afval leidt, omdat binnen Brinkers een sterk vermoeden bestaat dat er teveel potten naar de voedselbank gaan. Na het vaststellen van de norm kan Brinkers nagaan of dit daadwerkelijk het geval is. Echter kan het bij het correct registeren van afval (verbetering 3) wel voorkomen dat de kosten van afval hierdoor hoger worden. Het is belangrijk dat het management hier rekening mee houdt. Verbetering 3 en 4 samen zorgen voor meer grip op de afvalstromen, waardoor er ingegrepen kan worden als een afvalstroom ineens erg groot wordt. Het management is nu aan zet bovenstaande verbeteringen te implementeren, met behulp van het 11-weken implementatieplan in Tabel 2.

Acties	Actor	Weken
• Expert aannemen voor het ontwerpen en testen van de vulkop. • Het opstellen van een handleiding voor de productie hoe en wanneer deze vulkop gebruikt wordt. • Trainen van de werknemers in de productie over het gebruikt van de vulkop.	Plant Manager	4
• Creëren van kwaliteitskaarten voor de norm. • Trainen van werknemers over het gebruikt van de kwaliteitskaarten.	Quality Manager	4
• Creëren van codes in Exact waarop afvalstromen afgeboekt kunnen worden in Exact (IT afdeling). • Trainen van werknemers over het registeren van afvalstromen in Exact.	Production Manager	2
• Richtlijnen voor meetings opstellen en meetings organiseren.	Plant Manager	1

TABEL 2: IMPLEMENTATIEPLAN

We hebben een start gemaakt met het implementeren van de voorgestelde verbeteringen. We hebben een prototype gemaakt van de vulkop met statische menger, welke te zien is in Figuur 1. Het testen hiervan laat zien dat de strepen in de potjes verminderd zijn (Figuur 2), waardoor wij met de directie hebben besloten deze vulkop te implementeren. Daarnaast hebben wij een start gemaakt met het registreren van afvalstromen in het ERP systeem. De IT afdeling heeft codes aangemaakt in het ERP systeem en de vulafdeling heeft training gehad hoe ze de afvalstromen kunnen registeren.



FIGUUR 1: VULKOP MET STATISCHE MENGER

FIGUUR 2: LINKS: ZONDER STATISCHE MENGER, RECHTS: MET MENGER

Conclusie

We veronderstellen dat de meetmethode waarmee wij afvalstromen gemeten hebben voldoende betrouwbaar is om een goede conclusie te kunnen trekken. We adviseren Brinkers het stappenplan van Tabel 2 te volgen, zodat de aanbevelingen correct geïmplementeerd kunnen worden. Daarnaast adviseren wij Brinkers verder onderzoek te doen naar andere grote afvalstromen die niet onderzocht zijn in dit onderzoek. We raden aan om te beginnen met afvalstroom 20 en 21: de afvalstromen die resulteren uit de spoelmethode (Tabel 1), welke na afvalstroom 7a de grootste bleken uit onze metingen. Op basis van de metingen in dit onderzoek verwachten wij dat het registeren van de zes belangrijke afvalstromen het grootste deel van de kosten van afval van €X verklaren. Als op den duur blijkt dat er nog een te groot deel van de kosten van afval niet verklaard kan worden, kan de Impact matrix die we hebben gecreëerd gebruikt worden voor het selecteren van afvalstromen welke nog meer relevant zijn om te meten.

Definitions and abbreviations

Definition	Explanation	Introduced on page
BBD	Best Before Date, which indicates the expiring date of a product.	9, 25
Blocked Stocked	Products where a quality error has been detected. They may not be supplied (yet).	14, 25
Bottleneck	A process in a chain of processes which reduces the capacity of the whole chain by its limited capacity.	3
CMR form	A consignment note with a standard set of transport and liability conditions and which confirms that the carrier has received the goods.	9, 25
ERP	Enterprise Resource Planning, which is a software package that companies use to bring together important information from different business departments.	8, 14
Exact	The ERP system Brinkers uses.	14
FIFO	First in First Out, which is a way of inventory management where the items which are the longest on stock are sold first.	10
KPI	Key Performance Indicator, which is a measurable value that demonstrates how effectively a company is achieving key business objectives.	15, 19
Mixing planning	Planning for the department that mixes raw materials into chocolate spread, which includes the recipe number, the number of kilograms and the number of mixing kettles to be produced.	9, 23
Production order	A form with the details needed to produce the order, such as the number of trays in this order, the labels, the number of jars per tray or the number of trays per pallet.	8
Recipe	At Brinkers this is used as a synonym for specific chocolate spreads.	7
Recipe sheet	A form which indicates the quantities of all raw materials needed to produce a full mixing kettle of chocolate spread.	9
Shifts	Team of people that work together at the same time slot of a day.	7
Stakeholder	A person or group that influence a project and/or are influenced by it.	5

Content

1. Introduction

In the framework of completing my Master Industrial Engineering & Management, track Production and Logistic Management at the University of Twente in Enschede, I conducted my graduation thesis at Brinkers Food B.V. in Enschede. This research focuses on the reduction of waste of chocolate spread generated during production. Chapter 1 introduces the research. Section 1.1 introduces the organization. Section 1.2 clarifies the research motivation. Section 1.3 describes the problem, followed by the research scope in Section 1.4. Section 1.5 explains the research goal, and Section 1.6 describes the research questions and approach. Section 1.7 describes the stakeholders of this research and Section 1.8 the deliverables. Chapter 1 concludes with the thesis outline in Section 1.9.

1.1. Organization

Brinkers is one of Europe's leading suppliers of chocolate spread and distributes its quality products worldwide. Brinkers was founded in 1889 by Bernardus Brinkers and was originally a small margarine trading company. Margarine was a new product used as a replacement of the more expensive butter. Shortly after the Second World War, one of Brinkers' sons started introducing a new product: Choba, see Figure 1.1. Choba is a chilled cocoa butter which is nowadays still produced at Brinkers. In the early sixties Choba was followed by Nusco, the now classic hazelnut chocolate spread. In 1993 a new factory was built in Enschede. Brinkers has over the years successfully developed brands in every segment of international marketplace and is widely recognized to be a unique specialist in the chocolate spread industry. Brinkers produces both conventional and organic chocolate spread, which brands are shown in Figure 1.2. The organic Chocolate Rhapsody and the conventional Chocolate Symphony are Brinkers' flagship brands. Brinkers also produces private label products such as X and X.

FIGURE 1.1: CHOBA

FIGURE 1.2: BRINKERS' BIOLOGICAL AND CONVENTIONAL BRANDS

1.2. Research motivation

Brinkers mainly supplies its products to supermarkets. In this market there is a lot of money to be made for supermarkets as everyone buys groceries. As the size of the market does not change so quickly, the supermarkets grow and shrink especially when they take customers from competitors or lose customers. To win customers from competitors, supermarkets mainly play the battle for the customer with prize fighters. A lower price in the supermarket often means a lower purchase price at the supplier. Supermarkets who have more stores and sell more, have market power and can negotiate lower purchase prices with suppliers, Brinkers in this case. It is important for Brinkers to meet the supermarket's demand and prices as there is a lot of competition on the market. For Brinkers to meet these prices and remain profitable, the production costs must be kept as low as possible. Brinkers sees opportunities to reduce the costs of waste that is generated during production. Therefore, Brinkers whishes a research into the waste generated during production.

1.3. Problem description

Brinkers currently faces the problem that the costs of waste generated during the production of jars with chocolate spread are too high. The upper limit for the total costs of waste generated during production is set at €X for 2018 by the management. This maximum is based on the total costs of waste from 2017, which were €X and the management aims to have less costs in 2018. Currently the management has too little insight in these costs and the specific waste streams to set a more well-founded target. Table 1.1 illustrates the monthly costs of waste generated during production in 2018 at the start of this research.

Jan	Feb	Mar	Apr	May	June	July	Aug	Total	Target
X	X	X	X	X	X	X	X	X	x

TABLE 1.1: COSTS OF WASTE GENERATED DURING PRODUCTION IN 2018 (BRINKERS, 2018)

In August as a result of a two-week maintenance stop of production, no waste was generated for two weeks. This explains the relatively low costs of waste generated during production that month. With this taken into account, it is already clear to the management that the maximum cost of waste of €X will be exceeded. In addition, the maximum of €X is still regarded as very high by the management, and they expect that this can be reduced. The management suspects that not all costs in Table 1.1 are caused by physical waste, but also by administrative inaccuracies that occur during the production. Various interviews with management and production employees show that there exists too little transparency into the waste streams that exist. What waste streams there are, how large they are and where to start with reducing them. Therefore, there is a need for this research.

The core problem is the discrepancy between the norm and reality observed by the problem owner (Heerkens & Van Winden, 2012) and is formulated as:

'The total costs of waste during production are estimated to be higher than €X in 2018, which is the norm.'

Currently it is only known that the total costs of waste are too high, it is not known what waste streams exist, how large these waste streams are and what causes them. This must first be investigated before we can propose solutions to reduce the waste streams. With this research, we therefore aim to identify all waste streams, measure and analyze the most important waste streams and give recommendations on how the largest waste stream can be reduced.

1.4. Research scope

To make the research suitable for the given time period of six months, this research only focuses on waste of chocolate spread. The waste of labels, plastic, cardboard or other residual waste is excluded in this research, as historical data and the experience of managers and production workers show that the waste of chocolate spread causes the largest costs.

1.5. Research goal

The first problem is that the waste streams lack transparency. We assume that mapping the production process reveals the waste streams of chocolate spread, including administrative inaccuracies, that are generated during the production process. The second problem is that it is not clear how and where to start with reducing waste streams of chocolate spread. We therefore indicate for all waste streams identified from mapping the process their importance of further analyzing them. Then we will quantify the most important waste streams by measuring them and we will give possible solutions to reduce these waste streams. We will give an implementation plan to help the management implementing these solutions.

1.6. Research questions and approach

After defining the problem and clarifying the objectives, we have defined the following main research question:

How can the amount of waste of chocolate spread during production be reduced to lower the production costs?

To systematically answer the main research question, we divide the research question into sub-questions, which together answer the main research question. We defined these questions in an IST (Bottleneck)-SOLL form. IST describes the current situation and SOLL the desired situation. We identify and analyze the bottlenecks, the waste of chocolate spread, that cause the gap between these two situations. At the SOLL we generate solutions for reducing waste of chocolate spread that lead to the desired situation. The path that we should take to answer each question is described.

1. What is the current situation at Brinkers? (IST)

- 1.1. How is the production process currently organized at Brinkers?
- 1.2. What KPIs are currently used to measure the amount of waste of chocolate spread?

To understand the current production process and how this is organized, we make on spot observations while we analyze the production process. We ask questions to employees of several departments who are involved in the production process. To answer question 1.1, we will give information about the products Brinkers produces, the production planning, the shifts in which is being worked and the actual process of producing jars of chocolate spread. We create process flow charts to support the process description. For question 1.2, we interview the finance manager and other involved parties to gather information on KPIs that are currently in place to measure waste of chocolate spread at Brinkers.

2. Where in the production process occurs waste and which waste streams are important to further analyze?

- 2.1. How is the performance on the KPIs of waste of chocolate spread currently measured?
- 2.2. Specifically, where in the production process is waste of chocolate spread caused?
- 2.3. Which of these waste streams are important to further analyze?

To reduce the waste streams of chocolate spread, we first need to define the waste streams and measure their performance in the current situation. First we describe how the KPIs from question 1.2, that are currently used to measure the amount of waste of chocolate spread are measured. We do this by interviewing the finance department and other departments involved. After this, we will zoom in on the specific waste streams that Exist. We do this by thoroughly analyzing the production process, but now focused on different waste streams that exist. We use literature to find different definitions of 'waste' and common categories of waste. With this we minimize the chance that we overlook a waste stream while identifying them. We map the identified waste streams on the flow charts of the production process we created in question 1. We cannot analyze all waste streams in this research and we will use literature to find a suitable method to prioritize the waste streams, based on the criteria frequency and impact. We combine this with the gut feeling of managers and production workers to select the most important waste streams that we will further analyze in this research.

3. For the important waste streams, what is the amount of waste per waste stream per month?

3.1. Specifically, how is the amount of waste per waste stream per month currently measured?
3.2. How can the amount of waste per waste stream best be measured?
3.3. What is the amount of waste per waste stream per month?

Based on the criteria frequency of occurrence and impact we determined whether a waste stream is important or not. We will now measure the performance of the selected streams. This gives us more information about their improvement potential. To make sure we will use all relevant already existing information, we will first describe how the waste streams are currently measured. Then we create a data collection plan and if needed we develop a method for measuring the waste streams. To develop this method for measuring, we will use literature, creativity and input from production workers and managers. We must take the validity and reliability of the measurements into account, for example by emphasizing the anonymity of the measurements to the production workers. We will first run a pilot after which we can adjust the method if needed.

4. **What causes can be given for these waste streams?**

We now have an overview of important waste streams and their size. Before we can give recommendations on how they can be reduced, we must first identify all causes of the waste stream. We keep categories of causes from the literature in our mind, to minimize the chance that we overlook causes. It is important to be aware that people who we ask about causes probably have their own ideas and interests that influence which causes they find important. To avoid being influenced by this, the sequence of collecting data in this chapter is very important. We must first think of causes for waste streams ourselves, before interviewing production workers and management. We will use literature on cause-effect diagrams, such as the Ishikawa diagram, to systematically map the causes of the waste streams.

5. What improvements can be made to reduce the cost of waste of chocolate spread at Brinkers? (Soll)

5.1. Wat are Brinkers' requirements and wishes for solutions?
5.2. What are possible solutions and what are their pros and cons?
5.3. Which solutions are most likely to work and what are their risks?
5.4. How can the solutions be implemented?

Now we take the first steps into turning the current situation into the desired situation, the SOLL, by eliminating or reducing the waste streams with solutions we will present in this question. It is important that we come up with solutions that are likely to be implemented at Brinkers. Therefore, we describe the wishes and requirements stakeholders have regarding possible solutions. We develop different solutions by using creativity, interviewing different departments and using knowledge of similar companies. We use the requirements for solutions, and interview managers and production workers to choose the best solutions. Last, we will provide an implementation plan that Brinkers can use to implement the solutions.

1.7. Stakeholders

The stakeholders are all the people who have a role in this research and have something to gain or lose as a result of the outcome of this research. To make sure solutions found in this research fit well with the stakeholders' expectations, the different stakeholders and their interest must be known.

Management: they are the problem owners. For them it is most important that the outcomes of this research give them tools to improve the process regarding waste of chocolate spread during production. It is important that there is support from all stakeholders for the solution, otherwise the implementation of the solution will not be possible. Also, it is important that recommendations that require investments repay themselves after a certain period. It is important to closely involve the management in the research, so that their interests are clear and taken into account.

Production workers: it is most important for them that their job does not get more complicated as a result of this research. To create cooperation for the data collection and making them support the solution of this research, it is important that the operators feel part of the research and outcome.

Quality Department: for them it is important that the outcome of this result has no negative effects on the quality of the products.

1.8. Deliverables

The following will be delivered at the end of this research:

- This report both for the University of Twente and Brinkers.
- An insight into the different waste streams of chocolate spread and their importance of being reduced.
- Recommendations on how the waste streams of chocolate spread can be reduced at Brinkers. This also includes an implementation plan and recommendations on how the waste streams can be quantified if needed.

1.9. Thesis outline

Chapter 2	Current situation at Brinkers (IST)
Chapter 3	Identifying waste streams and selecting important waste streams for further analysis.
Chapter 4	Measuring and analyzing important waste streams
Chapter 5	Solution generation (SOLL)
Chapter 6	Conclusion, discussion and further research

TABLE 1.2: THESIS OUTLINE

2. Current situation

Chapter 2 describes the current situation at Brinkers. Section 2.1 describes Brinkers production department. Section 2.2 describes the KPIs that are currently used to measure the amount of waste of chocolate spread generated during the production.

2.1. Brinkers production department

Section 2.1 provides an overview of Brinkers production department. Section 2.1.1 gives an overview of the products Brinkers produces, Section 2.1.2 describes the shifts in which production workers work to produce the products. Section 2.1.3 describes how the planner establishes the planning that determines the sequence in which these products are produced. Section 2.1.4 provides an overview of all steps in the production process of producing jars with chocolate spread. We describe the production process from receiving raw materials till the expedition of finish products. Section 2.1.5 describes the cleaning procedure in the filling department at a changeover of producing another chocolate spread.

2.1.1. Products

It is important that we have an idea of the different products that Brinkers' produces, as all these products can result in waste. Brinkers has more than 200 recipes of brown and white chocolate spread. Of this, around 80 recipes are conventional and 120 are biological recipes. Recipes are indicated by a number, for example R00041. There are also many types of packaging. Jars can have different shapes and weights, labels can be removable or non-removable, caps can be plastic or metal. Cover seals can be made of paper, aluminum or being absent (Figure 2.1). The type of packaging used mainly depend on the price segment in which the products are sold.

FIGURE 2.1: COVER SEALS

2.1.2. Organization

We will collect data for this research in the production department. In the production department is being worked in shifts. It is not known whether different shifts carry out their work in the same way and if for example less or more waste is generated in specific shifts (for example at night when there is no supervision). It is important to know in which shifts employees work at Brinkers, so that our measurements and conclusions we draw from this are reliable. We use this information during the identification of waste streams by asking questions we describe in Chapter 3 to persons in all teams. During measuring in Chapter 4 we will measure 24 hours per day, so that we take all shifts into account in the measurements. For the Root Cause Analysis in Section 4.3.2 and the solution design in Chapter 5, we make sure we use input from all teams by asking them questions as we will explain in Chapter 4 and 5.

In the warehouse people work in daytime in one shift with two persons. This department is responsible for all inbound operations (except for bulk deliveries, which definition can be found in Section 2.1.4.1.a), warehouse- and outbound operations.

In the mixing- and the filling department people work in three shifts of eight hours per day. There is the morning shift from 6 AM to 2 PM, the afternoon shift from 2 PM to 10 PM and the night shift from 10 PM to 6 AM. A workweek starts at Sunday 10 PM and ends at Friday 10 PM.

In the mixing department is being worked in shifts of two persons. This department is responsible for the raw materials warehouse and for mixing raw materials into chocolate spread, including the ball mills (Figure 2.4) and storage tanks, which will further be explained in Section 2.1.4. The mixing department is the bottleneck of the production, mainly caused by the ball mills which cannot work faster. To prevent the filling department from not having recipe to fill, two persons from the mixing department work on Saturday and Sunday from 6 AM to 2 PM. Employees all work in the same shift for a week, after which this rotates. This means that in three weeks time (or a multiple of this), employees all have the same number of morning,- afternoon- and night-shifts they work in.

In the filling department are two production lines. Production line 2 is mainly used for the standard 400-gram jars. Other jars are produced on production line 1. Both production lines can produce white, brown or both colors chocolate spread. In the filling department people work in shifts of seven persons. There is one team leader, two operators (each responsible for one production line), one person responsible for work preparations and shift transfer, two persons responsible for stacking trays on a pallet (one per production line) and one person responsible for the supply of jars on the lines. The filling department is responsible for filling the jars with chocolate spread, closing the jars, labelling the jars, packing the jars in trays, stacking these trays on a pallet, locating the pallet temporarily in the cold store and after this in the warehouse.

2.1.3. Production planning

The production is done according to a production planning. There is one planner at Brinkers and the production plan is mainly based on the orders that are placed by the sales department. These orders are placed under 'unplanned orders' in the ERP system and the planner needs to manually fit these orders in the planning. Brinkers also has several products that they produce on stock, for example if there is slack in the planning and a large order from a regular customer is expected. The planner then creates a production order himself and plans this. A production order is a form with the details needed for the filling department to produce the order, such as what type of jars, labels and caps must be used and what quantity must be produced. Appendix 1a shows an example of a production order. The planning made is discussed every Thursday with management and sometimes needs to be adjusted due to an urgent order.

The planner has many things that he must take into account. First, he looks at which products can best be produced sequentially based on jar size. When changing to a different jar size, the complete production line must be adjusted to fit the new jar size. The time this takes depends on the types of jars which are produced. Also important is which recipes can best be produced sequentially based on the recipe of the chocolate spread, for example allergens. All recipes can be produced sequentially, but the system must be cleaned in between. The time this cleaning takes and the amount of waste of chocolate spread generated in this cleaning, depends on the type of switch.

2.1.4. Production of jars with chocolate spread

We will now describe the actual production process of producing jars with chocolate spread. The production process starts with receiving goods. When an order goes into production, the raw materials are mixed into chocolate spread which then goes to the filling department. At the filling department, the chocolate spread is poured into jars and the jars are equipped with caps and labels. Jars are placed in trays and stacked on a pallet.

Finished pallets are placed in the cold store after which they are placed in the warehouse and are ready for expedition. Figure 2.2 illustrates the sections in which these processes are explained.

FIGURE 2.2: GLOBAL PROCESS DESCRIPTION

2.1.4.1.a Receiving bulk goods

At Brinkers a distinction is made between bulk goods and other goods. Bulk goods include beet sugar and oil. Other goods include all other raw materials and packaging, such as jars, caps, labels, cacao, butter and fat. The mixing department is responsible for receiving bulk goods. Once a truck with bulk goods arrives, the mixing department gets a call from the warehouse that a truck wants to unload. Beet sugar is stored in one large sugar silo and oil is stored in tanks. There are three tanks for organic oil and two tanks for conventional oil. The mixing department receives a CMR form (official consignment note) and a sample of the bulk good together with a cleaning certificate of the bulk good, which is checked by the quality department. The mixing department checks all documents, whether the seal on the truck is intact and if the number of the seal corresponds with the number on the CMR form. The current stock level is read in the system in the mixing department and is noted on the form for receiving bulk goods in Appendix 3. Then the bulk can be unloaded. One person from the mixing department monitors the position of the oil tank and switches the tank if the first tank is full. After finishing unloading, the new stock level is read and noted on the receiving bulk goods form in Appendix 3. The CMR form is signed and both the driver and Brinkers receive this signed form. The quality department books the quantity stated on the CMR form in Exact (instead of what has actually been received, resulting in waste stream 1 in Section 3.3).

2.1.4.1.b Receiving goods

The warehouse is responsible for receiving goods other than bulk goods. The planner orders goods and receives an order number and an expected delivery day and time. Once a truck arrives, the warehouse receives a call and the CMR form is received after which the pallets are unloaded. The BBD (Best Before Date) and the batch are compared with the information on the CMR form. The quantities of goods are manually counted (which can lead to waste stream 2 in Section 3.3). If a pallet is missing an annotation is made on the CMR form and the planner decides whether a subsequent delivery is needed or not. The quality department decides what to do with pallets if the batch number or BBD do not correspond with the CMR form or if pallets are damaged. Then the CMR form is signed, the truck leaves and the pallets are put on their dedicated location in the warehouse. The warehouse manually books the pallets in Exact. The warehouse creates an entry check form. This form must be stuck on the pallets, after which the goods are ready to be used.

2.1.4.2 Mixing

The mixing department has a mixing planning on which for example the recipe number, the number of kilograms and the number of mixing kettles of chocolate spread to be produced are stated. The planner always plans something more than what is needed for the production order (waste stream 3, which we will further describe in Section 3.3). When an order goes into production the mixing department uses a recipe sheet. A recipe sheet indicates the quantities of all raw materials needed to produce one full mixing kettle of 1000 kilograms of chocolate spread. Raw materials are pre-processed before they are added to the mixing kettle. Beet sugar passes a magnet, is sieved and milled, fat is melted and filtered, and hazelnuts are stirred so that the layers of oil and solid particles disappear (Figure 2.3). After this the dosing of raw materials starts.

FIGURE 2.3: STIRRING HAZELNUTS

First the liquid raw materials (oil, fat, lecithin and hazelnut) are added in the mixing kettle. The desired number of kilograms or liters can be entered in the control panel of each raw material after which the required quantity is poured into the mixing kettle. After dosing all liquid raw materials, the solid raw materials are added to the mixing kettle. Beet sugar is dosed by pressing a button on the control panel. Cane sugar, cacao, milk powder and soy flower are in 25-kilogram bags and are poured manually into the mixing kettle. The bags raw materials have a fixed location in the warehouse and are taken FIFO from the warehouse by the mixing department. Sometimes the exact number of bags raw materials are picked from the warehouse and sometimes a whole pallet is picked. This depends on the number of bags needed and everyone also has their own method which he prefers. Then the raw materials are mixed into a chocolate spread and pumped to buffer tanks.

Per finished mixing kettle the amount of chocolate spread made is booked in the production order in Exact, and automatically the raw materials used are debited from stock in Exact. In practice, there are two methods used. The second method is that the mixing department writes down the recipe number and the number of kilograms of chocolate spread mixed per mixing kettle. When the total number of kilograms is mixed, the chocolate spread made is booked in the production order in Exact. The first method is how it should be, the advantage of this method is that if a raw material is used that has for example a short BBD, Exact gives a notification. If the booking is done after finishing the order, an short BBD is noticed too late. Also the mixing department can be mistaken in the number of mixing kettles they have mixed, when they do not note each mixed mixing kettle (waste stream 4, which we will further describe in Section 3.3).

At the shift handover the mixing department writes in a book the recipe number down and the number of kilograms that are in the mixing kettles. The next shift uses this book to know what still must be made for a batch (which may lead to waste stream 5, which we will describe in Section 3.3). After mixing the raw materials into chocolate spread, the chocolate spread still has a granular structure and must be ground to achieve the right structure. This grinding is done with a vertical ball mill, see Figure 2.4. The ball mill grinds the granules still present by rotating a cylinder

FIGURE 2.4: BALL MILL

with steel grinding balls, causing the balls to fall back into the cylinder onto the chocolate spread to be ground which is being pumped up. After the chocolate spread is ground, it passes a sieve and a magnet which removes metal which might get off the steel grinding balls. Then the chocolate spread is pumped to the storage tanks. This is the last step of the mixing department and after this the filling department takes over production.

2.1.4.3 Filling

Before producing a new recipe of chocolate spread all pipes, kettles and cooling systems must be cleaned. In this section the process of filling jars is explained, assuming the system has been cleaned. The cleaning procedure in the filling department will be explained in Section 2.1.5.

The chocolate spread in the storage tanks does not have the correct outlet temperature yet. Therefore, the chocolate spread is cooled in the cooling system. The cooling system consist of a buffer tank, a heat exchanger which has a double wall in which cold water flows, cooling the chocolate spread, and a retour heating system, respectively number 1, 2 and 3 in Figure 2.5. The correct outlet temperature differs per recipe and is indicated on the production order.

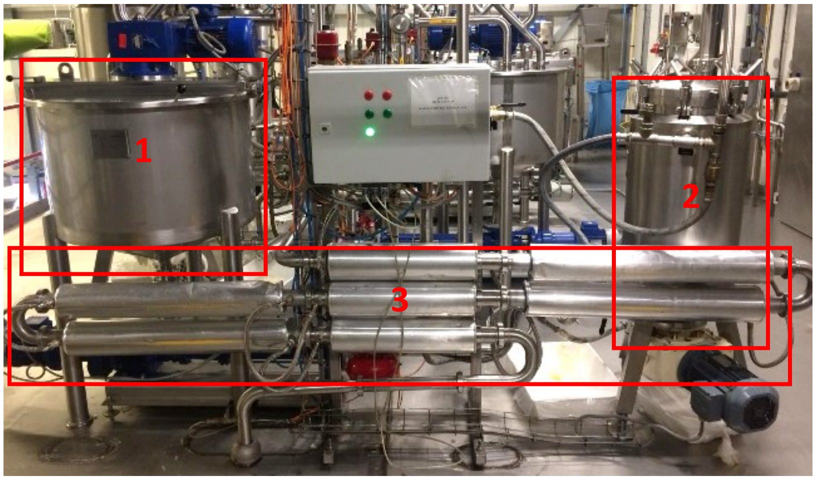


FIGURE 2.5: COOLING MACHINE

For some chocolate spreads a final action must be taken before it can be filled in jars:

- Chocolate spread must be aerated (Figure 2.6). The chocolate spread is pumped to an aerator where nitrogen gas is added to the chocolate spread, creating bubbles.
- Compound and crunch must be added.

FIGURE 2.6: AERATED CHOCOLATE

Parallel to the preparation of the chocolate spread for the filling machine, jars are added to the line. The jars are then turned upside down by the glass inverter so possible dirt falls out, after which air is blown into the jars to blow out the last dirt that may be in it. After this, jars are turned right side up and are filled with chocolate spread. Figure 2.7 illustrates the filling machine.

FIGURE 2.7: FILLING MACHINE

2.1.4.4 Packing and stacking

The jars are now filled and it is important that the actual weight of chocolate spread filled corresponds to the weight on the label of the jar. To verify this, jars are sample wise taken from the line and weighed. There are legal rules for how much the actual weight may deviate from the weight on the label and they differ for two groups of customers:

- European customers: here the ℮ weight applies, which means approximately. Meaning that for example the weight of 400 grams can also be 398 or 402 grams.
- Non-European customers: here the nominal weight applies. The weight of 400 grams on a jar means a jar requires at least 400 grams. To be sure of this, about four grams extra is always filled at Brinkers (leading to waste stream 15 in Section 3.3).

Then the jars go through a metal detector (Figure 2.8) after which the caps are supplied to the line (Figure 2.9).

FIGURE 2.8: METAL

FIGURE 2.9: SUPPLY OF CAPS ON LINE

FIGURE 2.10: COVER SEAL IN CAP

The jars then go through the glue machine which is turned on or off, depending on the type of cap that needs to be put on the jar. The caps that have a cover seal on the inside of the cap (Figure 2.10) are glued and due to the glue, the paper cover seal is attached to the jar. This is the prove that the jar is unopened and is called:

tamper-evidence. Jars can also be fitted a plastic cap with an aluminum cover seal or a metal cap without a cover seal.

After this the jars pass a sensor which checks if caps are missing or if they are turned skewed on the jars. Then the caps are labelled if needed, the batch code is printed on the label and the jars are labelled (Figure 2.11). Then jars go through the induction sealing machine (Figure 2.12). Only for caps with an aluminum cover seal this machine is turned on. Due to the heat of the induction sealing machine the tamper-evident seals in the caps are now stuck on the jars.

FIGURE 2.11: LABELING MACHINE

FIGURE 2.12: INDUCTION MACHINE

Then the cardboard trays are manually added to the machine (Figure 2.13) and are automatically folded in which six or twelve jars are placed (Figure 2.14). Depending on the order, a foil is shrunk around the tray and a tray sticker is added. After this the trays are manually stacked on pallets.

FIGURE 2.13: SUPPLY OF CARDBOARD TRAYS

FIGURE 2.14: PACKING TRAYS

Unfortunately, not all jars produced satisfy the product specifications. Jars containing small quality deviations are given to the foodbank. An example of jars given to the foodbank, is where the white and brown chocolate stripes in duo chocolate spreads are not evenly divided. These jars are stacked on a separate pallet which is given to the foodbank. If the jars are also not suitable to give to the foodbank, they are discarded. Meaning they are thrown away in containers which are located next to the production line. Each time this container is full, the container is emptied in a larger container as illustrated in Figure 2.17. These containers are collected by the waste management company.

During production, samples of jars with chocolate spread are taken for quality control (waste stream 16 in Section 3.3). Section 2.1.4.5 describes this quality check. The number of samples to be taken is stated on the production order. When stacking, these samples are put on top of the stacked pallets. After stacking, the finished pallets are checked by the team leader. Due to limited time, this is not always done (leading to waste stream 14 in Section 3.3). After finishing the production order, the trays are booked in Exact by the operator or team leader. The chocolate spread booked on the production order by the mixing department is automatically debited in Exact, as this chocolate spread is now poured in the jars.

2.1.4.5 Cooling, warehousing and expedition

The pallets and sample jars are cooled in a cold store for 6 to 8 hours, depending on the recipe and size of the jar. The pallets are placed in the cold store by the person responsible for stacking trays on a pallet. The person responsible for work preparations and shift transfer is also responsible for picking up pallets on time from the cold store (Figure 2.15).

After the cold store, the pallets are put in the warehouse. The samples put on top of the pallets, as explained in Section 2.1.4.4, are checked on their quality by Quality Control (QC), see Figure 2.16. If products do not meet their product specifications, they are temporarily put in blocked stock. Meaning they are blocked in Exact (the ERP system Brinkers uses) and the pallets are located on a separate location in the warehouse indicated with a 'blocked stock' sign. An action is needed before this stock can be unblocked, or the stock is destroyed (waste stream 18 in Section 3.3). After this quality check, the pallets are ready for expedition.

FIGURE 2.15: COLD STORE

FIGURE 2.16: QUALITY CHECK

2.1.5. Cleaning procedure in filling department

If a production order is produced and a new order with another chocolate spread goes into production, the cooling system (Figure 2.5), pipes and filling machine must be cleaned. This cleaning procedure exists of three steps and is explained with Recipe A being the recipe that has been produced and Recipe B the recipe that will be produced next:

First, Recipe A is still present in the cooling system and must be removed. By blowing air through the cooling system, most of Recipe A is moved to the buffer tank in the cooling system. This Recipe A present in the buffer tank must be discarded. First a container is placed on a pallet truck containing a built-in scale. This scale is set at zero, after which Recipe A is drained in a container until the buffer tank is empty (Figure 2.17). The weight of Recipe A drained is written down (waste stream 20 in Section 3.3). These containers are collected weekly by the waste management company, as described in Section 2.1.4.4.

Second, the traces of Recipe A in the cooling system must be removed. About 100 kilograms of Recipe B is pumped in the cooling system and circulated, so that the traces of Recipe A are washed away with the new Recipe B. The chocolate spread in the cooling system now mainly contains Recipe B, but also traces of Recipe A. This chocolate spread therefore must be discarded. This works the same as described above for recipe A. First a container is placed on a pallet truck containing a built-in scale. This scale is set at zero. Then the chocolate spread left, containing Recipe B (and traces of Recipe A), is drained in a container until the cooling system is empty. The weight of the chocolate spread drained is written down (waste stream 21 in Section 3.3). This container is also disposed to the waste management company. Now the cooling system is cleaned.

FIGURE 2.17: PALLET TRUCK WITH BUILT-IN SCALE

Third, the filling machine must be cleaned separately. With a scraper the Recipe A is manually scraped from the edge of the inside of the filling machine. Then the filling machine is filled with Recipe B and mixed well, so that the traces of recipe A are negligible.

Now jars are filled. The first jars at a start of a production do not have the correct weights and quality. These first jars are discarded in containers located next to the line, until jars are filled for more than half. Jars filled for more than half are given to the foodbank, as they can still contain traces of Recipe A, until the chocolate spread meets the correct quality. The waste of chocolate spread arising at the start-up of the production, which is either discarded or given to the foodbank is further described in Section 3.3, being waste stream 7. After this cleaning, the system, pipes and filling machine are ready fill recipe B into jars.

2.2 KPIs currently used to measure waste

As we described in Section 2.1, not all jars produced satisfy the product specifications. These jars are either given to the foodbank or discarded in containers, depending on the quality error. In between producing two different chocolate spreads, the cooling system and filling machine must be cleaned which causes waste of chocolate spread, as we described in Section 2.1.5. This waste is also discarded in containers. These containers are collected by the waste management company. To measure this amount of waste generated during production, Brinkers uses KPIs. Section 2.2 describes the KPI currently used at Brinkers to measure the performance on waste generated during production.

Currently, Brinkers uses the total costs of waste as KPI to measure the amount of waste during production. This KPI is not yet subdivided into the cost of waste of chocolate spread specifically. The KPI currently used is divided into three sub-KPIs. Section 2.2 describes these three sub-KPIs and describes which part of this explains the costs of waste of chocolate spread.

The KPI of the total costs of waste is divided in the sub-KPIs below. These KPIs are monthly monitored and targets are set for upcoming year. Together these KPIs form the total costs of waste as can be found in Table 1.1 in Section 1.3. Below we shortly describe each sub-KPI and in Section 3.1 we will elaborate on how each KPI is currently measured.

1. The value of jars with chocolate spread given to the foodbank. Jars with chocolate spread that have a small quality deviation, cannot be sold. These jars are put on a separate pallet which is given to the

foodbank, as explained in Section 2.1.4.4 and 2.1.4.5. This KPI uses the cost price of a jar of chocolate spread to calculate the value of jars with chocolate spread given to the foodbank. This cost price also includes the value of labels, caps and jars. All jars of chocolate spread that are given to the foodbank are registered and this data is used to set this KPI, which we will further explain in Section 3.1.

2. The value of chocolate spread and jars of chocolate spread discarded. All waste of chocolate spread that occurs at the production and which cannot be given to the foodbank, ends up in blue containers. These containers are collected and processed by the waste management company. This can be jars filled with chocolate spread as explained in Section 2.1.4.4, but also the waste of chocolate spread which is the result from cleaning the cooling system and filling machine between a product switch, as explained in Section 2.1.5. All this waste ends up in blue containers, which are collected weekly by the waste management company. The value of all waste in these containers sets this KPI. Not all waste that ends up in the blue containers is registered, which makes it hard to measure the value of all waste in these containers. In Section 3.1 we will explain how Brinkers currently measures this KPI.
3. The last KPI exists of all costs regarding the processing of waste at the waste management company. Meaning, all the bills Brinkers receives from the waste management company. This consists of processing all waste (including paper, plastic and cardboard and the rental of containers. Brinkers receives a reimbursement from the waste management company for the waste of paper, cardboard and plastic. This KPI partly is a result of the second KPI, meaning if we will lower the amount of waste in the blue containers, the costs for processing this waste will automatically become lower.

2.3 Conclusion

In this chapter we analyzed the current situation at Brinkers. Brinkers' products have a variety of product specifications that influence the production process. To produce the products, different departments in the production process work together. Products are produced based on a planning. The jar size and the switch from one chocolate spread to another influence the changeover time and the amount of waste generated in the changeover. The actual production process consists of several steps in which the raw materials are converted into a final product. In this chapter, we described the process in detail.

Unfortunately, not all jars produced satisfy the product specifications. These jars are either given to the foodbank or discarded in containers. Containers also contain waste of chocolate spread arising from cleaning the system during a productswitch. These containers filled with jars and chocolate spread are collected by the waste management company. To measure this waste of chocolate spread during production, Brinkers uses the KPI of the total cost of waste during production. This KPI is divided into three sub KPIs: the value of products given to the foodbank, the value of discarded chocolate spread and labels (which waste is collected by the waste management company) and the costs Brinkers pays for processing the waste.

There are many reasons why products end up in the waste containers or to the food bank. To find out how waste can be reduced, we need to gain more insight into these specific waste streams. We therefore will identify all waste streams in Chapter 3.

3. Identification of waste streams

Chapter 3 provides a detailed overview of the waste streams of chocolate spread generated during the production process. Section 3.1 describes how the KPIs of waste of chocolate spread as described in Section 2.2 are currently measured. In Section 3.2 we use literature to define waste and describe categories of waste known in literature. In Section 3.3 we identify all specific waste streams of chocolate spread generated during production, that together set the KPIs from Section 2.2. Section 3.4 provides an overview of the importance of further analyzing these waste streams, using a Impact Matrix.

3.1. Current way of measuring KPIs on waste

We will first describe how the KPIs used to measure the performance of waste during production, as mentioned in Section 2.2, are currently measured. We do this by interviewing the finance manager, the production manager and production workers.

The first KPI, the value of products given to the foodbank, is measured as follows: there is a separate pallet for trays that contain small quality deviations. These pallets are given to the foodbank, as explained in Section 2.1.4.4. The trays put on this pallet are noted on the production order. This production order is a form that contains all details that the filling department needs for production, as described in Section 2.1.3. An example of a production order can be found in Appendix 1a- Production order. The team leader or operator of the filling department uses the production order to debit the number of trays for the foodbank in Exact. They use different reason codes in Exact to indicate different quality deviations that jars can have, as can be seen in Table 3.1. We will further elaborate on these different quality deviations in Section 3.3, where we will describe all specific waste streams that occur during production. Monthly a file is extracted from Exact with an overview of the costs of products that are given to the foodbank, which sets this sub-KPI.

The second KPI, the value of discarded chocolate spread and jars of chocolate spread, is measured as follows. As described in Section 2.2, not all waste in the containers is registered. Therefore, at the end of each month, the production manager checks which recipes are in stock according to Exact. This is compared with all recipes that are stored in storage tanks. All recipes that are no longer in stock or in smaller quantities, are then debited in Exact by the Financial department.

In contrast to the products that go to the foodbank, this KPI is not further specified. Currently, this KPI is one large cost item where it is not clear why and where these costs have arisen. There are many causes why it can occur that recipes are not actual on stock while they are still on stock in Exact. This can be caused by several waste streams that are generated during the production process and by administrative inaccuracies (i.e., when a wrong quantity of mixed chocolate spread is booked in Exact). In order to find out where to start with reducing the waste of chocolate spread it is crucial to identify all waste streams of chocolate spread that occur during production. That is why we will identify all waste streams in Section 3.3.

The third KPI, all costs regarding the processing of waste at the waste, is set by all the bills Brinkers receives from the waste management company, which are booked in Exact. Figure 3.1 illustrates the monthly costs of waste at Brinkers per sub-KPI, which are measured as mentioned in this section.

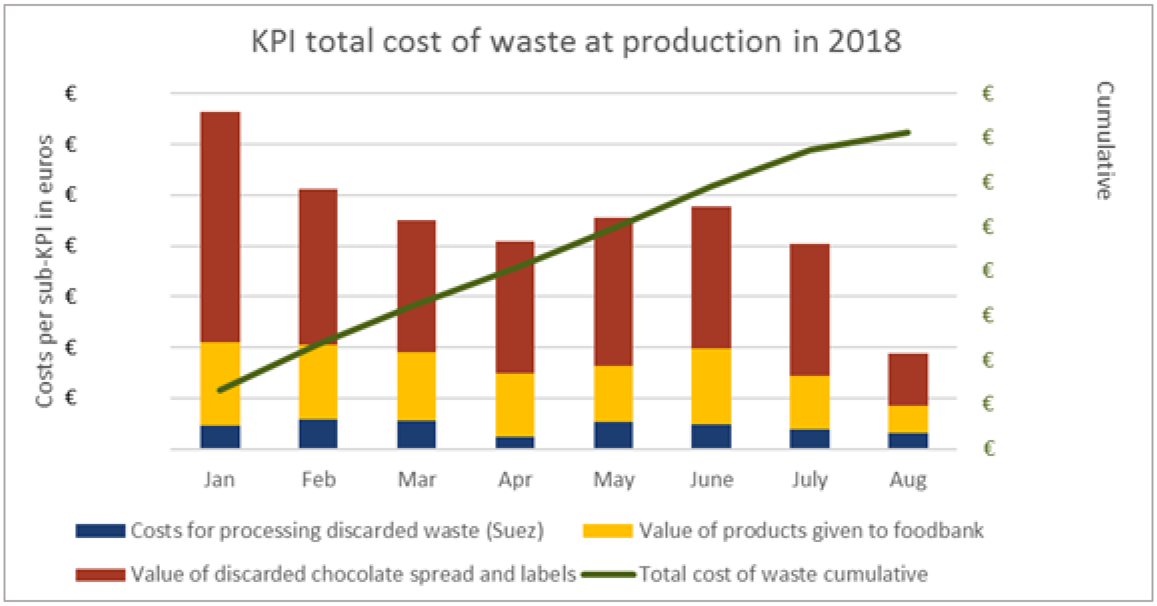


FIGURE 3.1: KPI ON COST OF WASTE GENERATED DURING PRODUCTION IN THE FIRST PART OF 2018

The total costs of waste from Figure 3.1 were already introduced in Table 1.1 in Section 1.3, which formed the motivation for this research. The sub-KPIs from Figure 3.1 have been measured in this way since 2018, therefore there is no accurate information on the performance on waste of chocolate spread available from previous years. In Figure 3.2 we further divide this KPI into the costs of waste of chocolate spread specifically, which this research focuses on. We exclude the costs arising from processing waste at the waste management company, as these costs cannot be divided into waste of chocolate spread specifically. This is not necessary either since Brinkers pays for the processing of the discarded chocolate spread per kilogram. If we lower the amount of waste of chocolate spread, the costs for processing this waste will therefore automatically reduce.

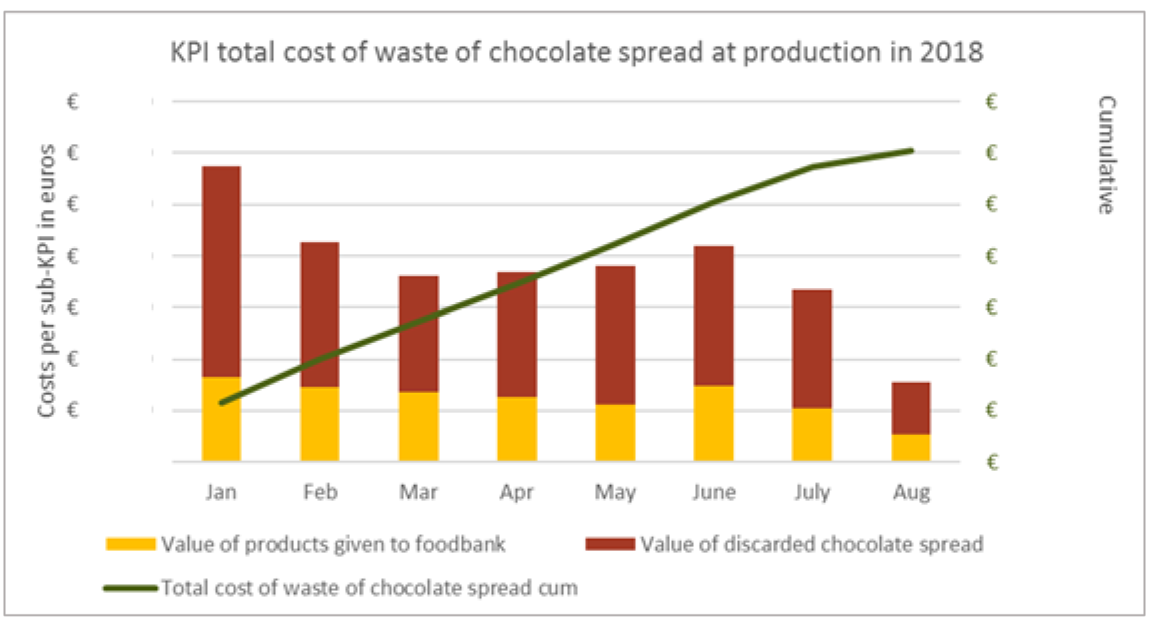


FIGURE 3.2: TOTAL COST OF WASTE OF CHOCOLATE SPREAD DURING PRODUCTION IN THE FIRST PART OF 2018

The KPI value of products given to foodbank is further divided into four categories. These specific waste streams are debited in Exact by using different reason codes. From this, an overview of cost per specific reason can be extracted from Exact. The result can be found Table 3.1. In Section 3.3, we identify all waste streams. The specific categories W1, W2, W4 and W5 from products given to foodbank from Table 3.1 are indicated as waste stream 8, 7, 12 and 13 respectively in Section 3.3.

Reason code	Jan	Feb	Mar	Apr	May	June	July	Aug
W1: stripes	€X	€X	€X	€X	€X	€X	€X	€X
W2: color	€X	€X	€X	€X	€X	€X	€X	€X
W4: label	€X	€X	€X	€X	€X	€X	€X	€X
W5: batch	€X	€X	€X	€X	€X	€X	€X	€X

TABLE 3.1: CATEGORIES OF PRODUCTS TO FOODBANK

The KPI value of discarded chocolate spread, has many causes (specific waste streams which we will introduce in Section 3.3) that together set these costs. This KPI is not yet subdivided into more specific waste streams. It is crucial to identify the specific waste streams, so that we can focus on the important waste streams to reduce and that most influence the costs. We therefore will identify all waste streams in Section 3.3.

3.2. Waste in literature

We now know which waste streams are currently already known at Brinkers (Section 2.2). For a large part of the waste of chocolate spread at Brinkers, specific waste streams are not known yet. The first step to reduce waste is recognizing that waste exists and identifying all waste steams. We use literature to get a more precise classification of the concept of waste at Brinkers and keep this is mind while identifying all waste streams in Section 3.3. In this way, we minimize the chance of overlooking waste streams.

Hicks et al. (2003) describes waste as something that has lost its primary function, but which can also have a second function such as serve as a raw material for another process. In lean manufacturing waste is called muda which is defined as anything that does not have value or does not add value to the customer. Following are the seven wastes, as categorized by Ohno (1988), the founder of the Toyota Production System:

1. Overproduction Making too many items or making items too early.
2. Waiting People, machinery or products waiting in the production cycle.
3. Transport Unnecessary movements of materials within the factory.
4. Overprocessing Processing beyond the standard required by the customer, e.g. oversized equipment.
5. Inventory Unnecessary storage of raw materials, components of finished goods.
6. Motion Unnecessary movements, such as walking, bending, stretching and reaching.
7. Defects Quality defects resulting in rework or scrap.

On top of these, Womack and Jones (1996) identified an eighth category of waste: non-utilized talent, which means unused knowledge or expertise available in the organization (Hicks et al., 2003).

By observing the process with our own eyes we get the understanding that category 4 and 7, respectively overprocessing and defects could be of relevance at Brinkers in this research. From Section 3.1 we see that registration errors in Exact affect the accuracy of these measurements, both in the sense that the registered waste is more than in reality and vice versa. This has no consequences for our research, because we are going to measure waste streams at the moment they arise, which is not influenced by the amount of chocolate spread that has been booked in Exact in which registration errors can occur. However, the registration errors do influence the KPI Brinkers currently uses to measure the amount of waste. Brinkers therefore wishes to investigate registration errors that cause waste as well.

We therefore define waste as:

'A physical form of product that loses its primary function during production, but which can also have a second function. We also include the registration errors in Exact that can affect the total amount of waste as measured at Brinkers.'

3.3. Different waste streams

As we found in Section 3.1, the value of products given to the foodbank and the value of chocolate spread discarded exist of several specific waste streams. It will be crucial to identify all waste streams and to do so, we observed the production department where relevant persons have shared their knowledge about waste in production. We asked questions such as: 'Can you explain me how this process step works?', 'Could (*specific situation which may cause waste)* occur?', 'Where do you think waste is generated?'. We started each conversation by showing interest in the production process and the responsibilities of the employees. By showing interest, people became more open and honest about waste streams. While doing this, we have kept the categories and the definition of waste from Section 3.2 in mind to minimize the chance of overlooking waste streams. In this way we identified 21 waste streams. These are shown in Table 3.2.

We have left out the waste streams that only occasionally occur (once in a few years). These are waste streams such as the overflow of a tank, or the burning of the chocolate spread in the ball mill (see Figure 2.4 for an example of a ball mill). Although some incidents can have quite a lot impact in terms of costs, we decided not to include them in this research, as there are still too many waste streams that often occur as a result of the current production process, which need to be focused on first.

We mapped the administrative flow of goods as settled in Exact by different departments at Brinkers and critically thought about whether this corresponds with reality. We verified this by interviewing employees and sample wise checking if possible. For example for waste stream 1, the quantity bulk goods received stated on the consignment note is booked in Exact. This raised us the question whether the quantity on the consignment note always matches with the actual quantity received, so if this booking is made correctly. Interviews with relevant people confirmed that waste arises here, as they suspect that it is likely to happen that there is received less than stated on the consignment note. If necessary we must find a way to measure the actual flow of goods, for example by using flow meters or scales. This way we get possible registration errors on the table. Registration errors (waste stream 1, 2, 5 and 14) can lead to overbooking and underbooking quantities in Exact. Overbooking means that more materials or chocolate spread are booked in Exact than the actual amount received or produced. Underbooking means the exact opposite. Although both situations occur, these two do not cancel each other in the registration. The reason for this is that overbookings is eventually always detected and corrected for in Exact, because when there is too little material or chocolate spread on stock to make a certain booking an error message in Exact pops up. The stock level must first be corrected before the booking can be done. Underbooking is not discovered as being a registration error and is therefore now assumed to be waste during production at Brinkers, as the materials are not on stock anymore. This is then debited in a specific 'waste group' in Exact, which bookings together form the total cost of waste in Table 1.1. and which is explained in more detail in Section 3.1.

Some of the waste streams in Table 3.2 have already been introduced in Section 2.1.4 and 2.1.5 and other waste streams are now described for the first time. We managed to visualize all waste streams in flow charts. The result of all waste streams identified can be seen below, and in Appendix 2. In the list below, we specify after each waste stream the corresponding appendix in which the waste stream is visualized on the flow chart. The color of each waste stream indicates their importance. Red indicates waste streams that involve high costs and green indicate waste streams that involve relatively low costs, orange and yellow are in between. This will be explained in Section 3.4.

Waste stream	**Description**
1 Out of scope	Incorrect booking in Exact of quantity of bulk goods (beet sugar and oil) received. The number of kilograms on the CMR form is booked in Exact, instead of the actual received quantity (Section 2.1.4.1.a). If the quantity received is less than stated on the CMR form, this is not noticed and therefore this is not corrected for this in Exact. This is waste of raw materials instead of chocolate spread and is therefore out of scope for this research as we defined in Section 1.4. (Appendix 2a- Flow chart receiving bulk goods)
2 Out of scope	Incorrect booking in Exact of quantity goods received. Received pallets and bags are manually counted, bags of raw materials are not weighed and goods are manually booked in Exact (Section 2.1.4.1.b). It can happen that the quantity goods booked in Exact differs from what has been received. This is waste of raw materials instead of chocolate spread and is therefore out of scope for this research as we defined in Section 1.4. (Appendix 2b- Flow chart receiving goods)
3	Overproduction of chocolate spread. This occurs when the mixing department has a mixing planning with a higher quantity of chocolate spread that must be produced than the planner has in his system, as described in Section 2.1.4.2. Besides the waste of time, this results in actual waste if the extra produced chocolate spread cannot be used for another customer. (Appendix 2d- Flow chart mixing raw materials into chocolate spread).
4	Incorrect dosing of raw materials. Liquid materials are dosed using dosing systems. These can be incorrectly calibrated. Solid raw materials are manually dosed by pouring bags of raw materials in the mixing kettles. It can occur that the number of bags of raw materials poured in the mixing kettle are miscounted. The process description of dosing can be found in Section 2.1.4.2. Often this wrong dosing of materials stays unnoticed. Then the quantity of chocolate spread booked in Exact differs from the quantity that has been mixed. This leads to extra chocolate spread booked in Exact being regarded as waste, which is included in the KPI of waste as it is now measured (as described in Section 3.1). (Appendix 2d- Flow chart mixing raw materials into chocolate spread)

5	Incorrect booking of quantity chocolate spread produced after mixing in Exact. This occurs for example if miscommunication occurs during the shift transfer (Section 2.1.4.2) on how many mixing kettles are mixed already. This leads to a wrong quantity of chocolate spread booked in Exact, which influences the KPI on waste as explained in waste stream 4. It can also lead to overproduction. (Appendix 2d- Flow chart mixing raw materials into chocolate spread)
6	Residues of chocolate spread remain in pipes and tanks. When chocolate spread flows through the pipes, kettles and buffers, residues of pasta are always left behind. (Appendix 2d- Flow chart mixing raw materials into chocolate spread)
7	At the start of the production after a product switch, the first jars are discarded if jars are filled for half or less. If jars are filled for more than half, but do not meet product specifications yet, they are given to the foodbank (Section 2.1.5). These jars can have the wrong weight or the wrong color. (Appendix 2e- Flow chart filling jars with chocolate spread)
8	The stripes in duo chocolate spread can be not equally divided (Appendix 2e- Flow chart filling jars with chocolate spread)
9	It occurs that jars are not filled full enough or too full. (Appendix 2e- Flow chart filling jars with chocolate spread)
10	Breakage of a glass jar. It occurs that a jar breaks during production. Jars in the vicinity of the broken jar must then be discarded, because they may contain pieces of broken glass. (Appendix 2e- Flow chart filling jars with chocolate spread)
11	Metal in jar detected by metal detector. (Appendix 2e- Flow chart filling jars with chocolate spread)
12	Jars which are not labeled correctly. Removable labels are removed, and jars are labeled again, but jars with non-removable labels are given to the foodbank. (Appendix 2f- Flow chart packing, stacking, cooling and warehousing)
13	Error in batch code. If labels are removable, the jars are labeled again, and the batch is printed again. If labels are non-removable, jars are either discarded or given to the foodbank. (Appendix 2f- Flow chart packing, stacking, cooling and warehousing)
14	Incorrect counting when stacking: stacking of trays on pallets is manually done. Therefore, it can occur that accidentally there is stacked a layer too much on a pallet, as explained in Section 2.1.4.4. If this is not discovered, a layer of trays is supplied to the customer for free. (Appendix 2f- Flow chart packing, stacking, cooling and warehousing).
15	Extra weight, meaning more than stated on the label, filled in jars is not taken into account in Exact. For non- European customers the nominal weight, as described in Section 2.1.4.4, applies. In Exact the weight stated on the label (e.g. 400 grams) is used in Exact to calculate the total number of kilograms of chocolate spread used to fill all jars. The actual weight filled is higher (e.g. 405 grams on average). This causes the extra chocolate spread filled in jars (5 grams in this example) still being

	in the storage tanks according Exact which is debited one a month, as explained in Section 3.1, and now seen as waste. (Appendix 2f- Flow chart packing, stacking, cooling and warehousing). As too little weight in a jar is a quality issue, all teams always fill some extra weight in jars just to be sure enough weight is filled in the jars.
16	Samples taken for quality control. These are the samples taken for each production order that are checked on quality by quality control (Section 2.1.4.5). After checking, the jars are discarded. (Appendix 2f- Flow chart packing, stacking, cooling and warehousing)
17	Quality Control check. Quality control checks the samples taken (from waste stream 16). If the quality is not good e.g., if the viscosity is not good or if the chocolate spread has shrunk in the jars, extra samples are taken to further analyze the batch. (Appendix 2f- Flow chart packing, stacking, cooling and warehousing)
18	Blocked stock. If quality deviations occur, due to incidents that occur during production, the batch is put in a blocked stock. Meaning, the stock is blocked in Exact and put in the blocked stock area in the warehouse. If the quality error cannot be removed or the stock is over its BBD, the blocked stock results in waste. This waste stream is explained in more detail in Section 2.1.4.5. (Appendix 2f- Flow chart packing, stacking, cooling and warehousing)
19	X
20	Cleaning: when switching from chocolate spread A to chocolate spread B the system is cleaned. Then (most) residues of chocolate spread A left in the system are blown through the system and discarded in a container. This waste stream is explained in more detail in Section 2.1.5. (Appendix 2g- Flow chart cleaning procedure in changeover in the filling department)
21	Cleaning: to make sure the system does not contain traces of chocolate spread A, the first +/- 100 kilograms of chocolate spread B is discarded in a container. This waste stream is explained in more detail in Section 2.1.5. (Appendix 2g- Flow chart cleaning procedure in changeover in the filling department)

TABLE 3.2: ALL WASTE STREAMS IDENTIFIED AT BRINKERS

3.4. Prioritizing waste streams

It is now crucial to prioritize the waste streams we identified in Section 3.3. This helps us to further focus in this research on the most important waste streams to reduce. To do so, we created an Impact Matrix (Paris, et al., 2007**)** to prioritize the different waste streams. An Impact Matrix is a tool that helps to prioritize risks in a visual way (Curtis & Carey, 2012).

We developed the assessment criteria for the Impact Matrix. We decided to assess the waste streams according to their frequency of occurrence and their impact on the costs of waste. These assessment criteria together form the total cost of waste which this research aims to reduce. We choose to assess the waste streams on an ordinal scale (Heerkens & Van Winden, 2012). The values of the variables on an ordinal scale are based on their relative ranking with respect to one another, but the exact value is unknown. This method is quick and easy and gives us sufficient information to rank the waste streams according to their importance.

We organized two group meetings with representatives from all parties involved. The Impact Matrix served as a guide in these meetings. This helped us to structuralize all thoughts and opinions of all parties involved about the importance of waste streams and come to one conclusion. It took interesting discussions to convince each other about the priorities of waste streams on the Impact Matrix. To prevent the outcome of this meeting to be biased, we clearly explained the purpose of the meeting: to get facts on the table about the importance of waste streams. We did not yet think about how, when and by whom these waste streams could be reduced.

During the meeting, we decided not to map waste stream 3 on the Impact Matrix. This is the waste stream of overproduction. Overproduction is often planned by the planner, for example to make up for the waste streams during production. Also, the mixing kettles require a minimal amount of chocolate spread to be mixed in order to function. Eventually, all chocolate spread that remains at the end of the production ends up in waste streams 18 or 19. Waste stream 3 is therefore already included in waste stream 18 and 19.

Together we established the Impact Matrix in Figure 3.3. The colors on the Impact Matrix indicate the importance of further analyzing and reducing the waste streams. Red indicates extremely important waste streams to further analyze and reduce and green indicates low importance for Brinkers.

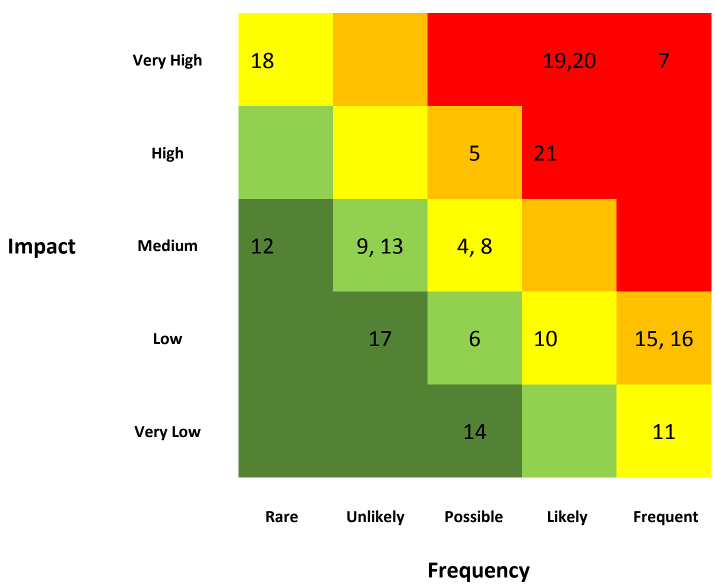


FIGURE 3.3: WASTE STREAMS VISUALIZATION ON IMPACT MATRIX

We decided to further focus in this research on all waste streams in the red and orange area, as these waste streams have the biggest impact on the amount of waste. In the meeting it became clear that waste stream 5 cannot occur when the current procedure is maintained as described in Section 2.1.4.2. Therefore, rather than measuring and analyzing this waste stream, we must make sure that this procedure is maintained. We do this by emphasizing the importance of booking each mixing kettle separately in Exact to the employees in the mixing department. If we still think it occurs too often, we can maintain the procedure by checking in Exact the times at which each mixing kettle has been booked, and number of kilograms that has been booked. From this we see when wrong bookings happened and by whom. There are six waste streams that we will further analyze in this research, which are waste stream 7, 15, 16, 19, 20, and 21.

3.5.Conclusion

We used literature to define the concept waste at Brinkers and kept categories of waste as defined in literature in mind to minimize the chance on overlooking waste streams. We identified 21 waste streams that are responsible for the cost of waste generated during production. We organized meetings in which we used the Impact Matrix as a guidance to prioritize waste streams. This helped us to combine thoughts of different parties involved in a structured way. Eventually, we came to one conclusion of all waste streams mapped on the Impact Matrix. In Chapter 4 we will further investigate the six waste streams in Table 3.3 which are mapped as important on the Impact Matrix.

Waste stream	Definition
Waste stream 7	Jars that do not meet quality due to a product switch, exists of two parts: • 7a: jars in which the previous produced chocolate spread is visible in jars. • 7b: first jars that are not filled full enough.
Waste stream 15	Extra weight, meaning more than stated on the label, is filled in jars.
Waste stream 16	Samples taken during production for quality control.
Waste stream 19	X
Waste stream 20	Cleaning tanks and pipes in between a productswitch (first part: containing the previous produced recipe).
Waste stream 21	Cleaning tanks and pipes in between a productswitch (second part: containing the recipe that is to be produced next).

TABLE 3.3: IMPORTANT WASTE STREAMS

4. Measuring and analysis of important waste streams

Chapter 4 provides an overview of the amount of waste generated per important waste from Section 3.3. To gain insight into the chances of saving costs, we need an overview of the amount of waste per waste stream and their costs involved. This overview is the basis for taking appropriate actions to reduce the waste streams.

This chapter is divided into three sections. Section 4.1 describes the data collection plan. This data collection plan describes what data must be collected and what method(s) can best be used for measuring the waste streams. Section 4.2 describes the results of the measurements of the different waste streams. Section 4.3 analyzes the waste streams and maps the causes of the largest waste stream. Section 4.4 describes the role of the management in waste management. Section 4.5 concludes this chapter.

4.1. Data collection plan

In Section 3.3 we identified six waste streams that we will further analyze in this research. We now need to measure these waste streams in the current situation. This will help us to focus on most important waste streams and assess their improvement potential when we will generate solutions to reduce the waste streams in Chapter 6. To collect all data we need, we draw up a data collection plan (John, Meran, Roenpage & Staudter, 2008). A data collection plan is a scheme that shows in one overview how data are collected. Specifically, a data collection plan indicates what data are collected, how these data are collected, by whom these data are collected, how many data are needed and where these data are collected. Below we will describe each element of the data collection plan. The steps in de data collection plan set the structure of this Section, as visualized in Figure 4.1.

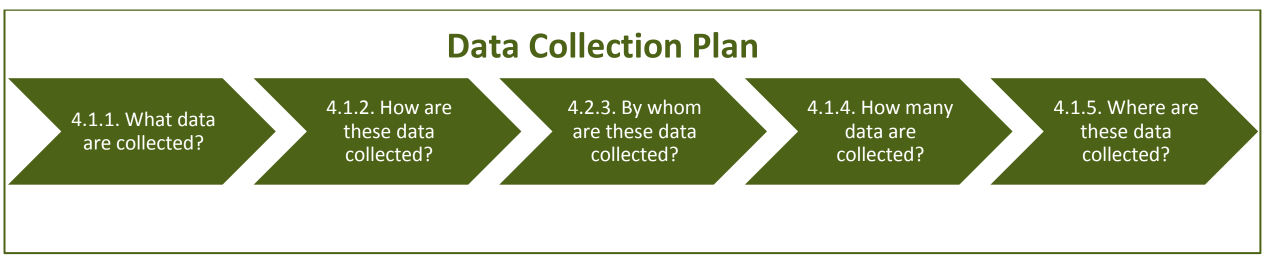


FIGURE 4.1: DATA COLLECTION PLAN WASTE STREAMS

4.1.1. What data is collected

We will measure the six waste streams 7, 15, 16, 19, 20 and 21, which we described in Section 3.3. The variable we measure is the amount of waste per waste stream in kilograms. The largest waste stream in terms of kilograms does not necessarily have to be the largest waste stream in terms of costs. The reason for this is that waste streams arise at different stages of the production process. Waste generated at the end of the production process consists of labeled jars filled with chocolate spread and involve higher costs than for example the waste of only chocolate spread at early stages of the process. We therefore convert the retrieved data into costs per waste stream, as this is what Brinkers aims to reduce.

4.1.2. How will this data be collected

The flow charts we created in Appendix 2 provide an overview of all steps that are needed to produce jars with chocolate spread. The purpose of these flow charts is to map out the current situation and to identify value added and non-value-added process steps and key process inputs and outputs. These inputs and outputs must be measured so that after making improvements, it can be assessed whether the changes have had an effect (Bañuelas et al., 2005). To do so, we considered using mass flowmeters in pipes. However, these are very expensive and currently not present at Brinkers, so we have decided not to purchase these and still weigh all waste streams as accurately as possible, which we will describe below.

To collect all data of waste during production, we created a waste registration form. This form can be found in Appendix 4. This form is to be filled out by the employees in the filling department. We must guarantee the reliability and validity of the measurements. Reliability means that other researchers must be able to generate the same results, by performing the same measurements (Heerkens & Van Winden, 2012). Validity refers to how well the measurements measures what it sets out to (Heerkens & Van Winden, 2012). We established the waste registration form through consultation with the stakeholders involved. With this, we guaranteed the involvement of the stakeholders in this research. In this way, the stakeholders feel responsible for the outcome of the measurements and this research. We expect this to contribute to the reliability of the measurements. We also emphasized the anonymity of the forms. To ensure the validity of the measurements, we have kept the waste registration form as simple as possible. We have also kept the way waste is weighed, which will be described below, as simple and fast as possible. We organized meetings with the employees from the filling department to explain the form and the purpose of collecting these data. We have taken into account that people work in day and night shifts and that everyone is informed. In order to fill out the waste registration form, waste streams must be weighed during production. How these different waste streams are weighed is explained below.

To make sure we use all useful information at Brinkers already available, we will describe the current way of measuring waste streams for the waste streams that are already being measured. We will adjust these methods if needed and we develop additional methods to measure waste streams that are not yet measured at Brinkers. The result can be found below, where we describe how we will measure each waste stream.

1. **Waste stream 7b: product switch (jars ≤ 50% filled)**

This waste stream is not measured yet. To measure this, we put a container next to the production line after filling the jars with chocolate spread. All jars that are filled half or less due to the start-up of the line, must be thrown away in this container. Each time the container is full, the container is emptied in a larger container which is placed on a pallet truck with built-in scale. The weights are written down on the 'waste registration form' in Appendix 4.

2. **Waste stream 7a: product switch (foodbank)**

The jars after this that are filled for more than half, but do still not meet product specifications, are given to the foodbank and are measured. After the stacking of trays on the pallet for the food bank, the number of trays is noted on the production order (see Appendix 1a). In Exact these trays are debited using reason codes. Reason code 'W2' for wrong color of chocolate spread is the result of a product switch (waste stream 7a).

3. Waste stream 15: extra weight filled in jars

This waste stream is not measured yet, but as described in Section 2.1.4.4 jars are sample wise taken from the line and weighed. These weights are written down on lists. We will collect these lists and use them to calculate the amount of chocolate spread extra filled in jars.

4. Waste stream 16: samples for quality

The samples taken for quality control are not measured yet. However, information on how many samples are taken is available. On each production order the number of samples to be taken is noted, as described in Section 2.1.4.4. We will collect these lists to measure the amount of chocolate spread discarded due to samples taken.

5. Waste stream 19: X

X

6. Waste stream 20: cleaning Recipe A (old chocolate spread)

This waste stream is measured by weighing the amount of chocolate spread drained in a container. This is done using a pallet truck with scale, as explained in Section 2.1.5. This is not registered in Exact. To check the reliability of the forms with discarded recipes (for both this waste stream and waste stream 21), we have checked randomly for a week whether the form has been filled out when needed. It often turned out to be forgotten. We therefore adjust this method slightly, which we think will help to make the measurements more reliable. Instead of writing this the weights of this waste stream down on a separate form, we will use the 'waste registration form' in Appendix 4 to gather the information. For each production order this form is to be filled out. We expect this to help ensure that the registering of the weights is not forgotten.

7. Waste stream 21: cleaning Recipe B (new chocolate spread)

This waste stream is measured by weighing the amount of chocolate spread drained in a container. This is done using a pallet truck with scale, as explained in Section 2.1.5. This is not registered in Exact and it turned out that this is not always registered, as explained in waste stream 20. Just as for waste stream 20 we will keep the current way of measuring, but we will now use the 'waste registration form' in Appendix 4 to gather the information.

We did a pilot study for three days, from November 28th until November 30th to test the data collection instrument. We did this to identify potential problem areas and deficiencies in the data collection instrument (Zailinawati, Schattner & Mazza, 2006) by analyzing the results and asking feedback from team leaders and operators in the filling department. After this pilot phase it did not appear necessary to adjust the method. The forms where correctly filled out and the team leaders and operators did not experience difficulties filling out the forms.

4.1.3. Who will collect this data

Team leaders and operators in the filling department collect the data by filling out the waste registration form in Appendix 5 as explained in more detail in Section 4.1.2. We will manually merge this data into Excel. This requires manual actions and is therefore not ideal. Brinkers wishes to integrate the different waste streams in Exact, so that in the future an overview of the different waste streams can easily be extracted from Exact. This will increase the insight into the costs of waste. For this research we have decided to first manually merge the data retrieved from the registration forms in Excel, so that after doing the measurements we can evaluate whether this method is suitable for measuring waste. In Chapter 5 we implement the registration of waste stream 20 and 21 in Exact. It is up to the management to implement the other waste streams in Exact in the future, as we describe in the implementation plan in Table 5.3.

4.1.4. Sample size and duration of measuring

For this research we measured the entire month December. This is from December 1st until December 21th due to the Christmas holidays. We measure for one month, because in the current situation the waste is measured per month. In addition, we choose this because data is then collected from more batches that are produced sequentially. The cooling system and pipes are cleaned in between, as described in Section 2.1.5. By acquiring data from both batches, dependencies of two different chocolate spreads on the amount of waste in waste stream 19, 20 and 21 is then taken into account.

4.1.5. Where will the data be collected

The data will be collected in the filling department in the production. We will measure the waste streams on production line 1 and production line 2.

4.2. Results of measurements

We measured from December 1st until December 31th. From December 21th to December 31th, there was no production due to Christmas. We made the following assumptions for the measurements:

1. For measuring waste stream 7, we assume that jars in the containers which is located next to the production line are filled on average for 50%. We made this assumption by sample-wise checking the jars in the containers. We use this to determine the ratio of glass and chocolate spread in the grey containers. There are different jar sizes (so different jar weights), which makes the ratio different for each combination of jar size and content. These ratio's can be found in Appendix 5.
2. To measure waste stream 19, X

For each production order that was produced the waste registration form (Appendix 4) had to be filled out. We used the planning to check the percentage of waste registration forms that were filled out. Out of the 137 orders produced, 128 forms were filled out on both production line 1 and 2, meaning that the response rate of the waste registration form is 93.4%. The results of the measurements as measured for 1st of December till 21st of December, can be found in the Table 4.1.

Waste stream	Waste (in kg)
7a	3913.7
7b	342.7
15	190.6
16	459.9
19	4862.0
20	1939.5

21	1544.0

TABLE 4.1: RESULTS OF MEASUREMENTS

We created the Impact Matrix from Section 3.4 again after measuring the important waste streams. The new classification of waste streams on the Impact Matrix turned to be slightly different than previously thought, as can be seen in Figure 4.2.

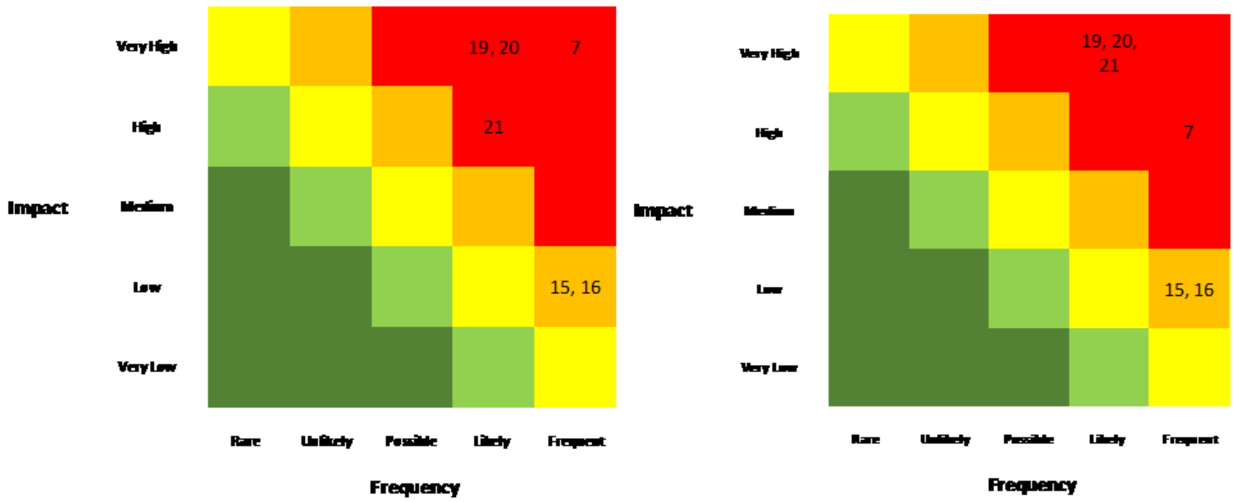


FIGURE 4.2: LEFT: IMPACT MATRIX BEFORE MEASUREMENTS, RIGHT: AFTER MEASUREMENTS

4.3. Analysis of results

4.3.1. Pareto chart

Based on the results of measurements from Section 4.2, we created the Pareto chart in Figure 4.3. The x-axis and the left y-axis are respectively the type of waste stream and the number of kilograms of the waste stream. The right y-axis visualizes the cumulative percentage.

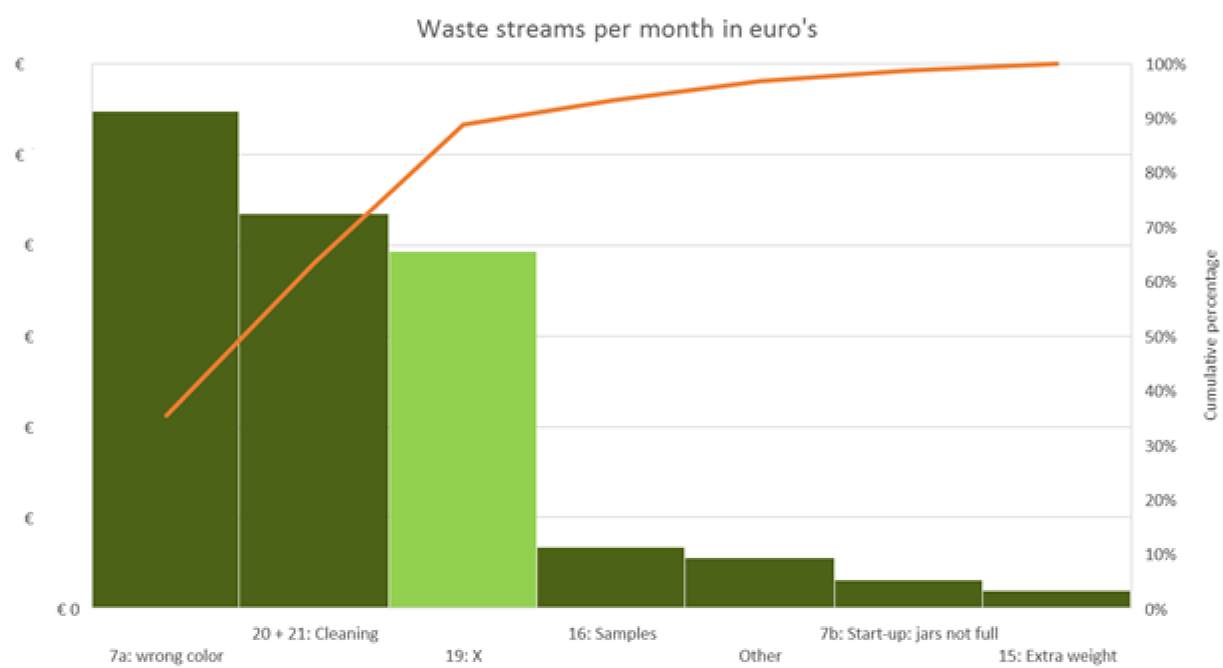


FIGURE 4.3: NUMBER OF KILOGRAMS OF WASTE PER WASTE STREAM, MEASURED FROM 1/12/2018- 31/12/2018

The waste stream 'other' consists of all the waste streams that exist, as described in Section 3.3, which we did not measure. Waste that is generated and not registered on the waste registration form (the 6.6% forms that are not filled out as we found in Section 4.2), is also included in the waste stream 'other'. When the percentage of waste that is registered becomes higher, we thus expect the waste stream 'other' to become lower. Waste stream 19 is given a bright green color, as this waste stream different from the other waste streams. X

Figure 4.4 illustrates the costs associated with the amount of waste per waste stream from Figure 4.3. To convert the waste streams to costs we multiplied the number of jars, trays or kilograms of recipe by the cost price of a jar, tray or kilogram of recipe, depending on the waste stream. The costs in Figure 4.4 indicate only the material costs, meaning the costs of chocolate spread, labels, caps and jars, and the costs for processing the waste. The products that go to the food bank are collected for free, but for the waste collected by the waste management company Brinkers pays €X per kilogram, which costs are included in Figure 4.4. The costs of man hours and machine hours are excluded. We expect that this will not influence the sequence of the waste streams in the Pareto chart. The reason for this, is that both waste stream 7a and the waste of cleaning (waste stream 20 and 21) take pretty much the same time, same machines, and involve an equal number of employees involved in these waste streams. We think that including man hours and machine hours waste stream 7a, 20 and 21 will become even larger compared to waste streams 7b, 15 and 16, because waste stream 7b, 15 and 16 take less time (both in machine hours and man hours) than waste stream 7a, 20 and 21. Taking the costs of man- and machine hours into account would therefore make the determinations of costs unnecessarily more complex.

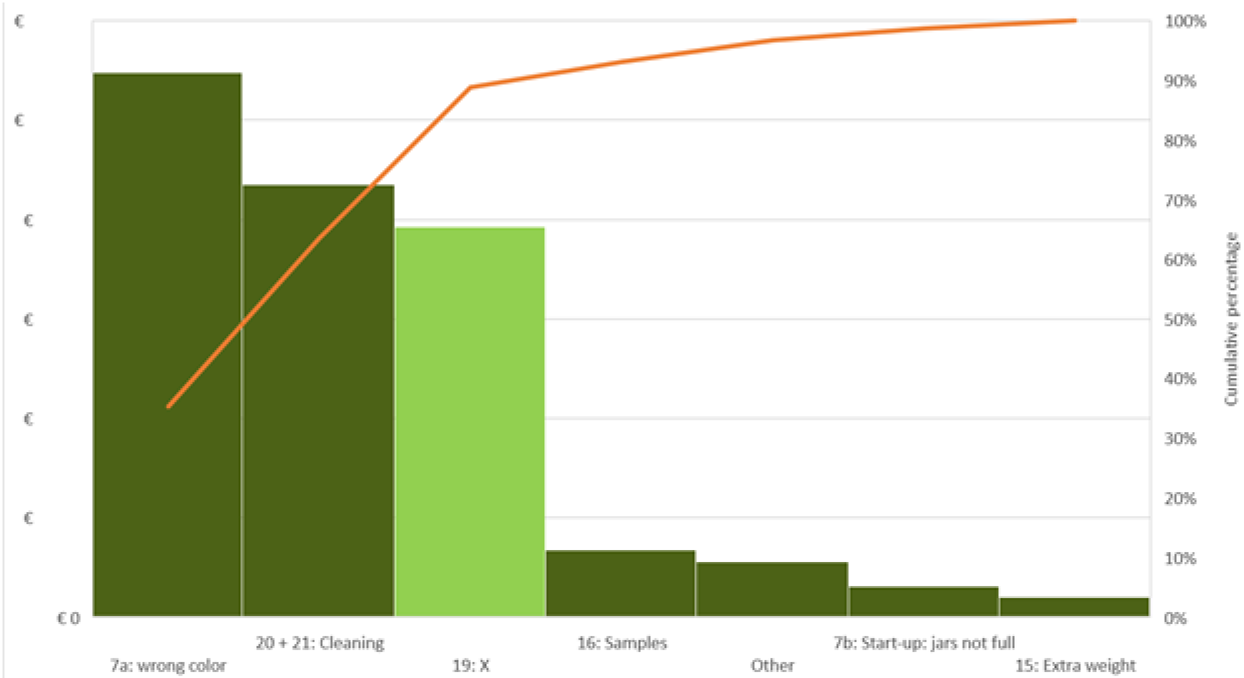


FIGURE 4.4: COSTS IN EUROS OF WASTE PER WASTE STREAM, MEASURED FROM 1/12/2018-31/12/2018

In the Pareto chart in Figure 4.4 the largest waste stream is now waste stream 7a instead of waste stream 19 which was the largest waste stream in Figure 4.3. The reason for this shift, is that the cost price of finished products (labelled jars filled with chocolate spread) is higher than the cost price of only the chocolate spread. In addition, the cost price of different recipes of chocolate spread varies from € X per kilogram to € X per kilogram, which explains other shifts from kilograms to euros. We determine which waste stream we will further analyze based on the costs per waste stream in Figure 4.4 and not on the number of kilograms per waste stream in Figure 4.3, because Brinkers wishes to reduce costs. According to the Pareto principle (or 80:20 rule), typically, roughly 80% of the effects come from 20% of the causes (Morgan & Brenig-Jones, 2016). When the 80:20 rule is applied to this Pareto chart in Figure 4.4 we can conclude that waste stream 7a, waste stream 20 and waste stream 21 are responsible for 80 percent of the total costs of waste of chocolate spread. We decided to further investigate the causes of largest waste stream 7a, which contributed to 50% of the overall costs of waste of chocolate spread.

4.3.2. Root Cause Analysis

To solve problems on structural basis, we must identify the root causes of waste stream 7a (Heerkens & Van Winden, 2012). We do this by identifying all potential causes of the waste stream. These causes are ideas of stakeholders and employees at Brinkers. With their input, we create an Ishikawa, or fishbone diagram (Morgan & Brenig-Jones, 2016). A disadvantage of a fishbone diagram is that the nature of the relationship between the causes and problems is not clear, so at first sight it is not clear what the core problems are (Heerkens & Van Winden, 2012). Despite this disadvantage, we have chosen to use the fishbone diagram, because this is a tool that is known and frequently used within Brinkers. In addition, the categories of 6M as we will describe below, guide employees to think of different aspects of the problem and think about causes that are not obvious. We reduce the disadvantage of the fishbone diagram by indicating the mutual relations of the causes in the fishbone diagram in Figure 4.5.

We will use the 5 Why- technique (Murugaiah, Jebaraj, Srikamaladevi, & Muthaiyah, 2010) to peel away the layers of symptoms of the problems. This will lead us to the root causes of the problems. The root causes are related to 6M (Smith, 2003). These categories are:

- Machinery: all equipment, computers, tools etc. required to perform the task.
- Material: parts, pens, paper etc. used to produce the finished product.
- Manpower: everyone involved in the process.
- Methods: how the process is carried out and the specific requirements that are put in place (policies, procedures, rules, regulations and laws).
- Measurements: data generated form the process used to evaluate the quality.
- Mother Nature (Environment): conditions such as location, time, temperature and culture, the way of working, around the process.

With the input of the production manager, plant manager and employees from the filling department, we identified all causes of waste stream 7a. The categories of 6M served as a guide for people to think of different elements relevant in the production process. We have discussed all categories of causes from literature, which minimizes the chance that causes are overlooked. We asked questions to identify causes for every category of the 6M, examples of these questions per category are:

- Machinery: *are there enough machines? Are the machines and tools regularly inspected? Is the maintenance of sufficient level?*
- Material: *is material clearly stored? Are items that are often needed within easy reach?*
- Manpower: *are people well-trained? Are people willing to improve? Is there enough experience available? Do people feel responsible for the problem?*
- Methods*: are there work instructions? Are they up to date? Are they used? Is there a structured way to train people in the best way of working?*
- Measurements: *is the waste measured? Are the results of these measures presented? Are there ways to manipulate the results of the measurements?*
- Mother Nature: *is there enough light in the workplace? Are there circumstances that affect the production process?*

The result is the fishbone diagram, as can be found in Figure 4.5. Some causes have the same overall theme. We merged these causes in one group by giving them the same color in the fishbone diagram. The colors indicate these groups. Table 4.2 indicates the groups in which the causes are classified, indicated by colors.

#	Cause	Problem statement
1 2 3	Polluted filling machine Chocolate spread cools down Chocolate spread is viscous	Cleaning the filling machine with water takes too much time. Cleaning without water currently generates too much waste because the chocolate paste sticks to the filling machine.
5	Too many jars given to foodbank	There is not clear what quality of products is expected for customers.
6 9	Many product switches Many different recipes/ colors	There are often short production batches, many different colors of recipes, and pull production, which makes options to combine orders difficult, causing many product switches.
8	Measurements may not be accurate	The amount of waste is not always correctly, because employees want to produce good quality products without generating too much waste.
4 7	Employees' lack of involvement Employees' lack of awareness of targets	Employees in filling department do not feel responsible for waste generated, as they are not aware of targets and how/ that they can influence this.

TABLE 4.2: OVERALL THEMES OF CAUSES

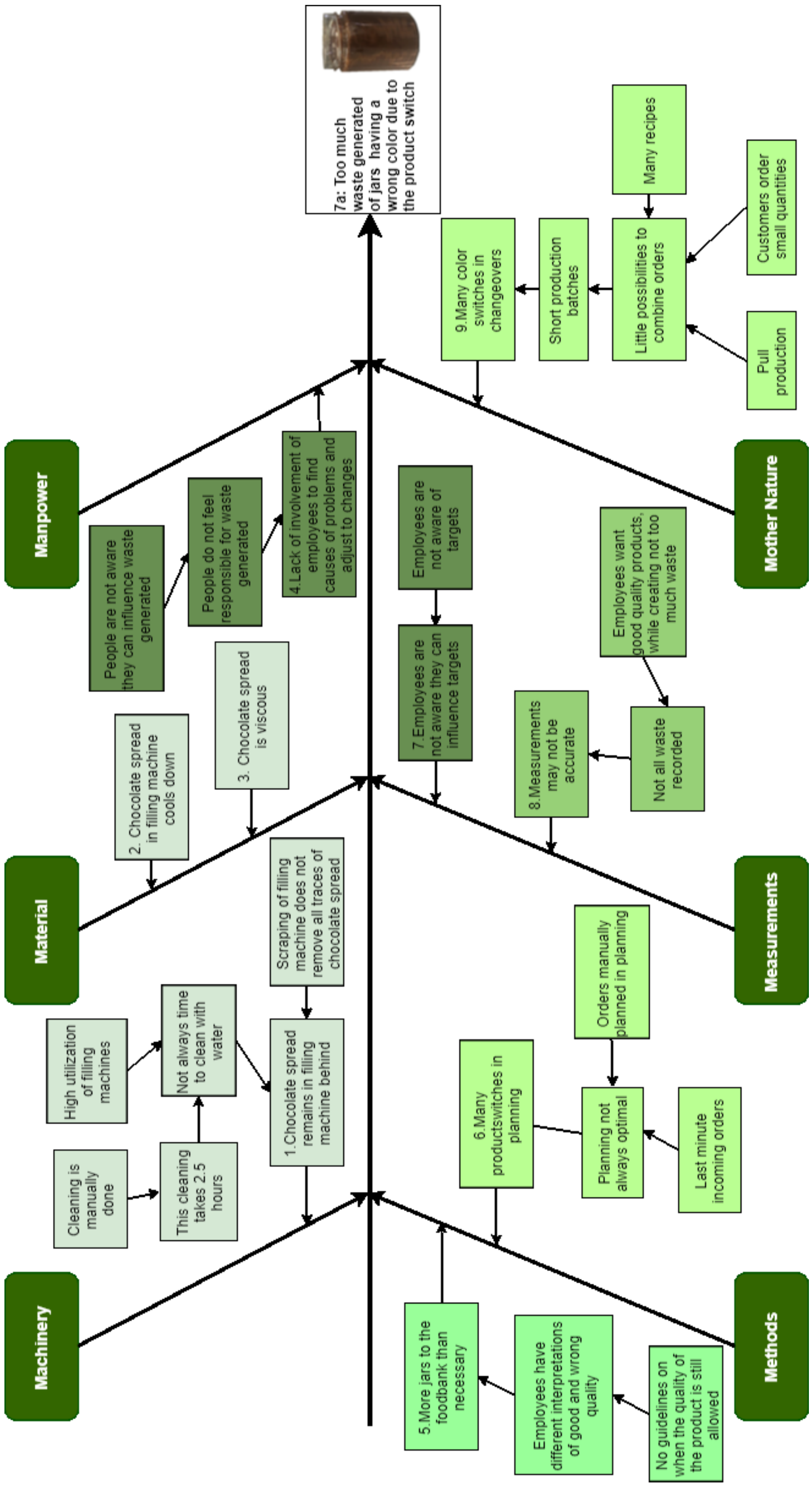


FIGURE 4.5: FISHBONE DIAGRAM WRONG COLOR DUE CHANGEOVERS

We now describe each problem from Figure 4.5.

1. Chocolate spread remains in the inside of the filling machine behind

When switching from one chocolate spread to a different chocolate spread, the inside of the filling machine is scraped with a scraper like the one in Figure 4.6. The figure on the left illustrates the filling machine for duo chocolate spreads and the figure on the right illustrates the filling machine for single color chocolate spreads. After scraping the filling machine is filled with the new chocolate spread, after which it is circulated in the filling machine to remove traces of the previous chocolate spread from the edges. Jars are then filled with the chocolate spread, but the first jars do not have the right color yet due to traces of the old chocolate spread which are still behind in the filling machine. Especially the filling machine for duo chocolate spreads is difficult to clean with the scrape, and the bottom of the filling machine and different other parts such as the filling tubes are not cleaned, causing waste stream 7a.

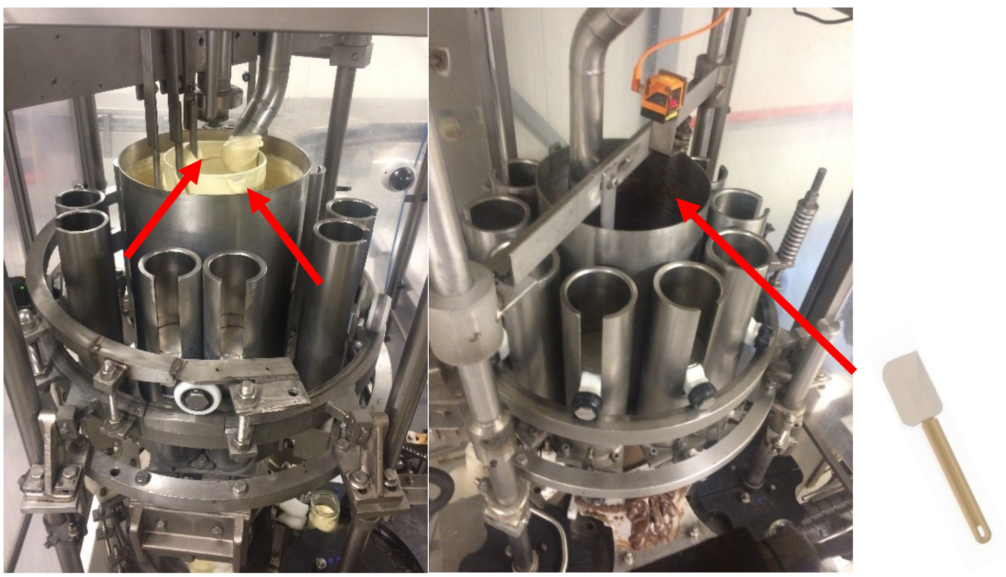


FIGURE 4.6: LEFT: FILLING MACHINE FOR DUO CHOCOLATE SPREADS, MIDDLE: FILLING MACHINE FOR SINGLE COLOR CHOCOLATE SPREADS, RIGHT: SCRAPER

When switching form chocolate spreads containing allergens to chocolate spreads not containing allergens, this filling machine is cleaned with water. This cleaning takes two and a half hour and doing this cleaning when switching from dark chocolate spreads to light chocolate spreads is not feasible. There is no time for this in the planning and the customer must be supplied on time.

2. Chocolate spread in filling machine cools down.

Each chocolate spread requires a specific temperature on which it can be filled in jars. A correct outlet temperature for example prevents shrinkage of chocolate spread in jars and other quality defects. The chocolate spread that remains in the filling machine cools down, causing it even more attached to parts in the filling machine. Employees are aware of this and therefore start scraping (Figure 4.6) immediately after filling the last jar of a batch, preventing the chocolate spread to stick to the filling machine even more.

3. Chocolate spread is viscous.

Due to the viscous nature of chocolate spread, it sticks to the filling machine.

4. Employees' lack of involvement

Employees are aware there is a lot of waste generated in the production, but they are not aware that they can influence the amount of waste generated themselves. Therefore, they do not feel responsible for the waste generated and are not motivated to find causes of this.

5. More jars to the foodbank than necessary

The employees in the filling department assess the quality of the products on their own insight and different people assess products differently. The quality department, production manager, plant manager and the employees in the production all strongly suspect that currently too many jars are given the foodbank. This means that jars having the correct quality are given to the foodbank.

The reason for this cause is that employees in the filling department only receive feedback on the quality of products and not on the amount of generated waste in production. As a result production workers want to be sure the quality is perfect to prevent this feedback and give some extra trays of jars to the foodbank. The quality department checks all samples taken during production (including the first jar that meets the correct quality according to the operator in the filling department) and is very strictly in assessing them. If the quality is not good according to the quality department, the jars produced around this time and meant for supply to the customer are then checked as well. This way, only the products that meet the quality specifications are delivered to the customer.

There is no hard evidence that currently too many jars are given to the foodbank and we cannot check this either because the norm of quality has not been established. According to Heerkens & Van Winden (2012) a problem is only put in the diagram is you are sufficiently sure that the problem occurs. This prevents you from solving a problem that turns out to be no problem afterwards. Despite this, we consider this cause as very important and because everyone at Brinkers is sure that this problem occurs, we decided to put it in the fishbone diagram, even though it is not proven that it is always the case that jars are unnecessarily given to the foodbank.

6. Many product switches in planning

Orders are manually fit in the planning by the planner. The planning is created based on experience and knowledge and might not always be optimal. In addition, sometimes there are rush order that cause the planning to be less optimal than desired.

7. Employees are not aware they can influence targets

Employees are not aware of targets on waste. Because of this, they do not know if these targets are met or not. They continue with their current way of working, because this seems good to them.

8. Measurements may not be accurate

Employees want to do their jobs well. This means that on the one hand they do not want to generate too much waste, but on the other hand they want to produce good quality products. In the current situation this combination is not possible. Therefore, there are three ways in which employees do their best they think they can do: the first is they create high quality products, while generating a lot of waste. The second way is they produce 'less quality' products while generating less waste. The third way is they produce high quality products and generate a lot of waste, but do not register this correctly which makes this stays unnoticed. Currently, employees have the idea that it often occurs that the amount of waste is not registered correctly, although everyone says to do so their selves.

9. Many different recipes/ colors

There are many different colors of recipes, customers often order small quantities of products and Brinkers produces demand-driven. Therefore, there are not so many options to combine orders in the planning causing short production batches with many product and color switches. There are many switches from dark chocolate spreads to light chocolate spreads, causing a lot of waste.

Through the analysis of the fishbone we have discovered a more fundamental management problem, which we will describe in Section 4.4.

4.4. Role of management

By analysing this problem in Section 4.3, we have discovered a more fundamental management problem. Employees in the production department are in between different interests of the management. Meaning on the one hand the costs of waste must be kept as low as possible, but on the other hand the quality of products must be perfect. In the current situation this combination is not possible. Therefore, there are three ways in which employees do their best they think they can do in this situation: the first is they create high quality products, while generating a lot of waste. The second way is they produce 'less quality' products while generating less waste. The third way is they produce high quality products and generate a lot of waste, but do not register this correctly which makes this stays unnoticed (or anonymous). This problem is related to causes 5 and 8 from the fishbone diagram, as described above in Section 4.3.2. In Chapter 5 we provide the management with advice and possible improvements regarding the waste management at Brinkers.

4.5. Conclusion

Within this chapter we measured the six dominant waste streams from Section 3.4. We further analyzed the largest waste stream, so called waste stream 7a which are jars having a wrong color due to the productswitch.

We conclude that there are multiple reasons for the existence of this waste stream. During a root cause analysis, we found nine potential causes and we described a more fundamental management problem. In Chapter 5 we will present improvement actions to reduce the number of jars having a wrong color due to the productswitch.

5. Solution design

Based upon the analysis in Chapter 4, we defined root causes of waste stream 7a. This chapter provides solutions to significantly reduce this waste stream. First, in Section 5.1, we determine criteria for solutions, after which Section 5.2 describes the brainstorm session with relevant people, organized with the purpose of generating ideas to solve the root causes. In Section 5.3 we reduce the number of ideas using the selection criteria from Section 5.1. Section 5.4 provides an implementation plan for the solutions and Section 5.5 concludes this chapter.

5.1. Requirements for solutions

It is important that we come up with solutions that are likely to be implemented at Brinkers. Before elaborating on solutions for the causes we found in Section 4.3.2, we first describe the wishes and requirements stakeholders (as described in Section 1.7) have regarding possible solutions. We use these constraints to make a selection of the ideas which result from the brainstorm session in Section 5.2.

1. All orders must be produced and must be supplied on time. The production planning is tight and the solution must take this into account. For example: cleaning the filling machines in between a product switch with water (which will prevent this waste stream) is not an option, unless the capacity is increased by buying new filling machines. Capacity of the current filling machines cannot be increased.
2. We cannot influence the demand from the customer. It is out of scope for this research to negotiate with customers about the agreements Brinkers and customers have on for example minimum order quantities or the number of different recipes a customer can order.
3. Limited amount of available space in the filling department. The solution must fit in the filling department. Expansion possibilities or are out of scope for this research.

There are no preconditions for the investment required, as long as we can show that a solution is worth the investment. Furthermore, as the cost of waste is currently too high and the sooner costs can be saved, the better. It therefore is desirable that the solution can be implemented on short term. Longer term recommendations can also be given.

5.2. Potential solutions

We describe the process of generating ideas which minimizes the root causes as depicted in Section 4.3.2 in this section. We kept Lansink's waste control hierarchy in mind while generating ideas to be sure that we have thought of all options to reduce or manage waste. Ad Lansink is international recognized for making the original waste hierarchy or 'Lansink's Ladder' in 1979 (Wolsink, 2010). The waste hierarchy can be found in Figure 5.1 and aims to identify the options to reduce and manage waste from most favorable to least favorable for the environmental outcome (Papargyropoulou et al., 2014).

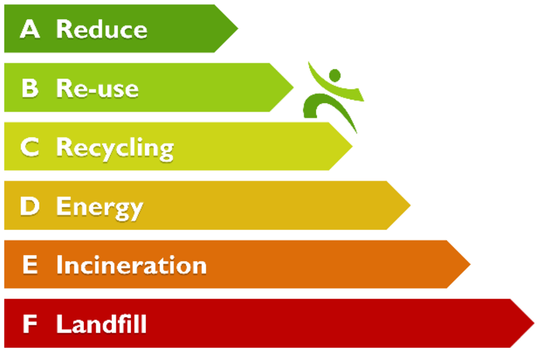


FIGURE 5.1: WASTE CONTROL HIERARCHY- LANSINK'S LADDER (WOLSINK, 2010)

The options to reduce and manage waste from Figure 5.1 are:

- Reduce: the generation of waste is prevented or minimized.
- Re-use: recovery through product reuse
- Recycling: recovery through material reuse
- Energy: recovery as a fuel
- Incineration: incineration with energy generation
- Landfill: dumping

By generating ideas to reduce the costs of waste, we involved people from all departments and organized several brainstorm sessions where we followed the following brainstorm rules (Higgins, 1996): 1) postpone feedback, 2) the more ideas the better, 3) stimulate creativity, and 4) stimulate improving ideas of others. We have presented the specific problem and asked people for input. People have also shared their knowledge about other companies, such as at one company where oil is used to rinse pipes in a food branch, another employee has seen a movie of a filling machine with a built-in cleaning robot. We have asked questions related to the waste hierarchy, such as: 'how do you think we can prevent or reduce waste?', 'do you have ideas about how we can separate the jar from the chocolate spread, so that we can reuse the chocolate spread?'. In addition, we used literature to see how other companies reduce or manage waste. Unilever has a zero-waste policy. Since 2011 they have a biodigester that converts waste, such as waste of ice-cream and water, into biogas which is then used to heat up the building and to purify water. The plant is 100% climate neutral and the plant provides for its own heat requirement (Unilever, 2014). In China, production waste from one Procter & Gamble facility is composted and used as "nutritional soil" for local parks. A site in India is turning scraps into wall partitions for homes and offices, roof tiles, low cost shoes, car wash components and so on.

We wrote down all ideas that have been generated to reduce waste stream 7a, which overview can be found in Appendix 6**.** We will now further elaborate on the solutions that have most potential and meet the requirements of Section 5.1 for the causes as we identified in Section 4.3.2. Table 5.1 describes the required improvements and the section in which we describe the improvement action.

#	Name of cause	Improvement	Section
1 2 3	Polluted filling machine Chocolate spread cools down Chocolate spread is viscous	There is a need for the filling machine to be adjusted, replaced, or an adjustment must be made in the current method of change overs in a way that less color switches in jars occurs.	5.2.1
5	Too many jars given to foodbank	Expected quality for customers must be defined and its correctness must be regularly checked by quality.	5.2.2
6 9	Many product switches Many different recipes/ colors	None- we cannot influence customer demand and orders are when possible already combined in the planning.	-
8	Measurements may not be accurate	Improve data registration by integrating measurements on waste streams in Exact.	5.2.3
4 7	Employees' lack of involvement Employees' lack of awareness of targets	Employees must become more aware of targets set for waste and what role they can play in this.	5.2.4

TABLE 5.1: IMPROVEMENT ACTIONS FOR WASTE STREAM 7A PROPOSED DURING BRAINSTORM SESSIONS

5.2.1. Static mixer in filling tubes

The amount of 'old' chocolate spread which ends up in jars causes color stripes in the jars. The extent to which this color stripe is visible, differs per jar. Figure 5.2 is an example where the color strip is clearly visible. However, in many jars that are given to the foodbank, the color stripe in the jar is very minimal and does not affect quality of the recipe. The reason these jars are given to the foodbank, only is because the 'old' chocolate spread is visible. To ensure that the 'old' chocolate spread which remains in the filling machine is not visible in the jars, we have come up with the following solution.

FIGURE 5.2: COLOR STRIPE

We want to mount a static mixer in the filling tube. A static mixer is a devise for the continuous mixing of fluid materials, without moving components. A static mixer consists of a tube with molded parts, the so-called mixing elements, which ensures that the flow profile is disturbed in such a way that everything is mixed into one homogeneous mixture, as Figure 5.3 illustrates. The motionless characteristic makes the mixer low maintenance and a long service life.

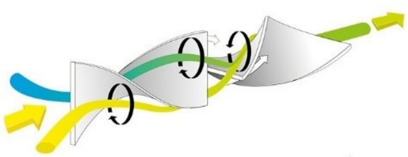


FIGURE 5.3: EXAMPLE OF A HELICAL STATIC MIXER

We want to mount the static mixer in the filling tube, because this is the last point where two colors of chocolate spread flow through, before it is filled in the jars. Many static mixer designs can achieve the desired result, but the optimum static mixer is the one that delivers the desired mixing quality, at the lowest pressure drop, for lowest installed cost and fits the space available. A combination of empirical observations/ experience and analytical modeling is needed for selecting and designing the best static mixer. For this research, it is out of scope to design the optimal static mixer. However, we decided to make a prototype of the filling tube with static mixer, which is shown in Figure 5.4

FIGURE 5.4: PROTOTYPE OF FILLING TUBE WITH STATIC MIXER

The static mixer is detachable, so that it can be removed when the color difference of chocolate spread in jars is no longer visible. We expect that we need to lower the filling speed slightly when the static mixer is mounted in the filling tube, because the static mixer is a resistance that we add in the filling head. We therefore decided to make the static mixer detachable, so the static mixer can be removed and the filling speed can be increased for the production when the color difference is no longer a problem. We must test the filling tube with static mixer to see if it works as we expect and if it works, to what extent the problem of the color difference has been solved. The flow rate of the chocolate spread during filling, the length and the diameter of the static mixer and the design of the static mixer all influence the performance of the filling tube on this waste stream. These are all factors to take into account when designing the filling tube with static mixer.

It is important for Brinkers to set the norm for quality. This norm can be used to determine from which jar in the production the amount of chocolate spread that ends up in the jar is negligible and meets the quality expected by customers. We will discuss this norm in Section 5.2.2.

5.2.2. Cards on required quality

It is important that everyone within Brinkers maintains the same norm for the quality of products. This norm is currently not set and it is important this will be done. Quality department is responsible for determining these norms, which can differ per customer (group). The norm can be defined and handled by creating quality cards, in which for example the range of accepted stripes in jars and the color of each specific recipe must be defined. Production then uses these quality cards as a benchmark to assess whether a product its quality is allowed or not.

In Section 4.3.2 we explained that it is highly unlikable that currently wrong quality products are supplied to the customer, due to the strict quality check on samples taken during production. As we also explained in Section 4.3.2 we suspect that currently too many jars are given to the foodbank. To verify if the norm is used by the production department, samples should also be taken from the pallets which are given too the foodbank. Through a feedback mechanism from the quality department towards the production, we think that the number of jars wrongly assessed will decrease. It is not certain whether this solution reduces the costs of waste, because we are not 100% sure if it is indeed the case that too many jars are given to the foodbank.

However, we still recommend implementing this solution because it is important that the norm for quality is defined in order to supply a constant quality to the customer.

5.2.3. Waste registration in Exact

It is important that waste streams are registered in Exact for several reasons. First of all, this will contribute to the correct determination of the amount of waste generated at Brinkers. The correct waste registration in Exact can also lead to higher costs of waste, so it is important that the management is aware of this. We expect the registration of waste streams in Exact to contribute to reduce waste streams, as registering them provides a better grip on the waste streams. Immediate actions can be taken if a waste stream suddenly becomes very high. Without registering waste streams, such high peaks in waste would not even be noticed. Additional benefits of registration are for example that the accuracy of stock levels of jars, lids, chocolate spread and raw materials will improve. If the waste streams are not registered, the products that resulted in waste remain on stock in Exact. Incorrect stock levels can cause an out of stock to be noticed too late. Last, it is necessary to register waste streams in Exact to assess whether improvement actions to reduce waste have an impact or not and to determine the payback period of an investment.

We recommend measuring the extended overview of the KPIs on waste in place, as can be found in Table 5.2. A more detailed description of the KPIs can be found in Section 2.2 and in Section 3.2 where we described the different waste streams. We recommend measuring the extended KPIs indicated with a yellow color as we did during the measurements, as explained in Section 4.1.2. Instead of filling out the separate waste registration form, the production order can be adjusted so that waste can be filled out on this form. We already adjusted the production order (Appendix 1b) so that waste stream 20 and 21 can be registered. Also, instead of manually combining all information in Excel we recommend debiting these waste streams in Exact, so that useful data is generated on waste.

Code	Costs per category (Section 2.2 and 3.2)	Waste stream (Section 3.2):	Generate data by:
C1.0a	**Total costs of waste**		= C1.00+ C1.10+ C1.20+ C1.30
C1.00	Costs for the processing of waste at the waste management company:		= C1.01+ C1.02+ C1.03
C1.01	* Costs environment and recycling		Extract from Exact
C1.02	* Yields from paper/cardboard/plastic		Extract from Exact
C1.03	* Rental of waste containers.		Extract from Exact
C1.10	The value of products given to the foodbank, consists of:		= C1.11+ C1.12+ C1.13+ C1.14
C1.11	* Wrong color	7a	Extract from Exact
C1.12	* Wrong stripes	8	Extract from Exact
C1.13	* Error in labels	12	Extract from Exact
C1.14	* Error in batch	13	Extract from Exact
C1.20	The value of chocolate spread and labels discarded:		= C1.21+ C1.22
C1.21	- Chocolate spread, consists of:		= C1.21.01+ C1.21.02+ C1.21.03+ C1.21.04
C1.21.01	* Startup (grey bins) **(New)**	7b	Extract from Exact ▪
C1.21.02	* X **(New)**	19	Extract from Exact ▪
C1.21.03	* Cleaning: Recipe A **(New)**	20	Extract from Exact ▪
C1.21.04	* Cleaning: Recipe B **(New)**	21	Extract from Exact ▪
C1.21.05	* Other		Extract from Exact
C1.22	- Labels		Extract from Exact
C1.30	Samples **(New)**	16	Extract from Exact ▪

TABLE 5.2: OVERVIEW OF EXTENDED KPIS. AN ▪ INDICATES THAT THIS WASTE STREAM IS NOT INTEGRATED YET IN EXACT

We decided not to include waste stream 15, the extra weight filled, because the effort to measure this waste stream is too high compared to the impact this will make, as the costs this waste stream involve are is relatively low (see Section 4.3). We integrated waste stream 20 and 21 in Exact. The other new waste streams are not integrated yet in Exact. When these waste streams are not integrated in Exact, they will end up under the waste stream 'other'.

5.2.4. Involve employees

Targets on waste have been set by the management, but the waste is generated in the production and the employees in production are not aware of these targets. Involving employees is a tool to achieve the goal of making them aware of the amount of waste. We expect this to contribute to employees recognizing the importance of for example accurate determining whether products meet the norm of quality or not. Meetings can be organized with the production department. In this meeting the overview of amount of waste per waste stream as can be extracted from Exact (as we explained in section 5.2.3), can be discussed. We recommend to weekly update and print this overview and to place this in the production department. We expect the meetings to contribute to valuable insights of the waste streams. For example, if a certain waste stream suddenly becomes very high the management can notice this from the data on costs, but needs input and ideas from the production (as they are fully involved in the production process) to get possible causes on the table. We can conclude that involving employees does not have to directly contribute to reducing the costs of waste, but it is possible.

5.3. Best solutions

We recommend implementing the solutions as we proposed in Section 5.2.1 to 5.2.4. We expect that the solution in Section 5.2.1 will reduce the costs of waste stream 7a. Testing different designs of the filling tube with static mixer will have to show whether this solution reduces the waste and to what extent.

The solution in Section 5.2.2 will help to determine the actual costs of waste by defining the norm of quality. We also expect that this will reduce the costs of waste, as we expect the number of jars that are unnecessary given to the foodbank to reduce. The second is likely but does not necessarily have to be the case and implementation will have to prove this as we explained in Section 5.2.2. We expect the solution in Section 5.2.2 not to have a negative impact on the costs of waste, because of the strict quality control on outgoing products (as we explained in Section 5.2.2).

The solution in Section 5.2.3 helps us to register the waste streams and thereby keep a grip on the waste streams. This helps to assess whether improvement actions to reduce waste have an impact or not and to determine the payback period of an investment. Registering waste streams is important to get a grip on the waste streams. Immediate actions can be taken if a waste stream suddenly becomes very high. An additional advantage of registering is that the accuracy of stock levels increases, as a result of which for example out of stocks are noticed earlier. We can conclude that registering waste streams does not have to directly contribute to reducing the costs of waste, but it is possible.

The solution we proposed in Section 5.2.4 of involving employees does not necessarily reduce the costs of waste. Nevertheless, we believe it is important that employees in the production department are aware of the targets set by the management and the amount of waste generated in production, because we think this will have advantages such as stimulating the employees to think of possible causes of a high peak in the waste streams in a certain period.

In Section 4.4 we have discovered a more fundamental management problem. We would like to advise the management to determine what quality is worth to them in terms of costs. If the management wants higher quality, the costs of waste will probably also become higher and vica versa. To manage expectations, it is important for the management to be aware of this.

5.4. Implementation plan

We have come up with ideas to reduce the cost of waste, but further steps must be taken to actual reduce the costs of waste. The ball is in management's court now to implement the proposed improvements. The following 11-week schedule in Table 5.3 indicates which actions should be undertaken by whom and when, so that the solutions can be implemented correctly.

Actions	Actor	Weeks
• Hire an expert to design and test the filling tube with static mixer. • Create a manual on how and when to use the filling tube with static mixer. • Train employees in production how to use the new filling tube.	Plant Manager	4
• Develop cards on required quality for products. • Train employees in filling department how to use the quality cards.	Quality Manager	4
• Create reason codes in Exact for each waste stream (IT department). • Train employees in filling department on how to register waste in Exact.	Production Manager	2
• Create an outline of the meeting and organize the meetings.	Plant Manager	1

TABLE 5.3: ACTION PLAN FOR IMPLEMENTING IMPROVEMENTS

In this research, we already created a prototype of a filling tube with static mixer in Figure 5.4. We tested this and Figure 5.5 illustrates the result of the test. The left jar illustrates the difference of using the static mixer (right jar in Figure 5.5) and not using the static mixer (left jar in Figure 5.5). Testing is done after a productswitch from producing a chocolate spread containing 30% cacao (dark chocolate spread) to producing a chocolate spread containing 7.5% cacao (lighter chocolate spread).

FIGURE 5.5: LEFT: WITHOUT STATIC MIXER, RIGHT: WITH STATIC MIXER

From this result we conclude that the filling tube with a static mixer contributes to reducing the costs of waste. We therefore decided to produce extra filling tubes with static mixer, so that they can actually be used at Brinkers (as there are five mixers needed for one filling machine). We also already executed and implemented the registration of waste stream 20 and 21. This must still be done in the same way for the other waste streams.

5.5. Conclusion

In this chapter we have described how we have come up with solutions and explained how they can be implemented by Brinkers' management to achieve the desired situation (SOLL). We first defined Brinkers' wishes and requirements for solutions. We then used Lansinks' waste control hierarchy and used the knowledge of other companies from literature, which we combined with knowledge and ideas from all employees at Brinkers to come up with solutions. We found four improvement actions, namely:

1. Design and implement static mixer in filling tubes.
2. Establish the norm on the required quality of products.
3. Correct waste registration in Exact.

4. Involve employees in the targets for waste set by the management.

Testing the filling tube with static mixer has shown us that improvement action 1 directly helps to reduce the costs of waste. We expect improvement 2 to reduce the costs of waste, as within Brinkers there is a strong suspicion that too many jars are given to the foodbank. After setting the norm, Brinkers can check whether this is actually the case. Both improvement action 2 and 3 will contribute to the correct determination of the amount of waste. However, by implementing improvement 3, the correct waste registration in Exact can in theory also lead to higher costs of waste. It is important that the management is aware of this. Improvements 3 and 4 together provide a better grip on the waste streams, so that immediate action can be taken if a waste stream suddenly becomes very large. The ball is in management's court now to implement the four improvements, with the use of the 11-weeks implementation plan we created.

6. Conclusion, Discussion and Further Research

Chapter 6 provides conclusions and feedback on the research and recommendations. In Section 6.1, we provide conclusions by answering the main research question. In Section 6.2, we reflect on the research. We elaborate on the recommendations regarding items outside the current research scope and suggestions regarding future research in Section 6.3.

6.1. Conclusions

The objective of this research, as formulated in Chapter 1, is to identify all waste streams and to measure and analyze them. We use this data to give Brinkers advise on how the waste streams can be reduced. Together these results answer the following central research question:

How can the amount of waste of chocolate spread during production be reduced to lower the production costs?

The results of this study show that there are 21 waste streams at Brinkers, if we leave out incidental waste streams that only occur once in a few years. From these 21 waste streams, there are six dominant waste streams that are most important to tackle, based on their frequency of occurrence and their impact on the costs of waste. Waste stream 5 is one of these dominant waste streams and cannot occur if the procedure of booking each mixed mixing kettle of chocolate spread separately in Exact is maintained. It is therefore important to emphasize the importance of maintaining this procedure to the employees in the mixing department. Exact also has the function to check who has made an incorrect booking. For the other important waste streams, measurements show that waste streams 7a, 20 and 21 are responsible for 80% of all generated waste in production, in which waste stream 7a consists of jars having a wrong color due to a productswitch and waste stream 20 and 21 both result from cleaning the system in a productswitch.

We developed four improvement actions to reduce the waste of jars having a wrong color due to a productswitch, so called waste stream 7a.

1. Design and implement static mixer in filling tubes.
2. Establish the norm on the required quality of products.
3. Correct waste registration in Exact.
4. Involve employees in the targets for waste set by the management.

We would like to advise the management to determine what quality is worth to them in terms of costs. If the management wants higher quality, the costs of waste will probably also become higher and vica versa. It is important to be aware of this, so that the expectations can be managed.

We partly implemented these solutions, by implementing waste streams 20 and 21 in Exact and by designing a prototype of the filling tube with static mixer. Now, the ball is in management’s court to take the required actions to implement all solutions we proposed. We created an implementation plan to help Brinkers implementing the solutions. Not all these solutions necessarily reduce the cost of waste, but it is possible and it has many advantages to implement these solutions. To manage expectations, it is important that the management is aware of this.

6.2. Discussion

In this research there are some limitations that may have influenced the results. We call these limitations discussion points and discuss them below.

First, it might be possible that the waste registration forms are not always filled in correctly, for example that less waste is written down than there actually was. As explained in Section 4.3.2 in cause 8, this is due to the fact that in the current situation the combination of not generating much waste, while producing good quality products, is not possible. From our data we see that about 319 kilograms of waste can not be explained. This may have been caused by this limitation, but also by waste streams that we did not measure.

Second, during the measurements in total, out of the 137 orders produced, 128 forms were filled out on both production line 1 and 2, meaning that the response rate of the waste registration form is 93.4% (Section 4.2). We want this response rate to be 100%, meaning that for every production order, the waste is registered. This would make the ratio of the different waste streams to each other more reliable, allows us to make better estimates of possible savings, and would result in a higher accuracy of the stock levels in Exact.

Third, the period of measuring affects the amount of waste. December was a short month due to the Christmas holidays, as a result of which the measurements in this month are not entirely representative for other months.

We do not expect the limitations we mentioned above to change the measurements in such way that the sequence of waste streams in the Pareto Chart have changed. In addition, the waste stream that we analyzed is still very large, and therefore still important to tackle.

6.3. Recommendations

To conclude this research, we provide some recommendations for Brinkers. These recommendations are based on the result of this research and the discussion.

We advise Brinkers to implement the improvements we proposed step by step by using the implementation plan in Table 5.3.

In this research we managed to analyze and propose improvements for the most important waste stream. It will be worthwhile for Brinkers to also analyze other important waste streams. The Pareto chart in Section 4.3 gives a good overview of the sequence in which the waste streams are important to be analyzed. We recommend updating this overview with data collected over a longer period of time after registering the waste streams in Exact. If the waste streams are not registered yet, we recommend starting with analyzing waste stream 20 and 21, as these are clearly significantly larger than the other waste streams. Research can then be done into how these waste streams can be reduced.

In the first place, we do not recommend measuring the waste streams that we have not classified as important on the basis of the Impact matrix in Figure 3.3, because the matrix shows that we expect these waste streams to be very small. It therefore takes unnecessary time to register these and Brinkers should focus on the important waste streams first. However, if after registering the important waste streams it appears that too many costs of waste are still inexplicable (which we do not expect), we then recommend measuring other waste streams as well. The Impact matrix can be used to see which waste streams to measure next. In this way, the gap of waste that is not made clear yet can be further reduced.

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Appendix

Appendix 1a- Production order operator CURRENT/OLD

PRODUCTIE LIJST OPERATOR

PRODUCTIE ORDER:	PR1871809103.001	**DATUM:**	04/02/2019	**DAGCODE:**	(03519)

VERKOOP ORDER:		**VOORRAAD**
KLANT:		**Muscat**
ARTIKEL:	3632288-4	Nusica Hazelnut/Milk Duo Spread RSPO-SG 12/200

Artikelgegevens:

						Aantal kg	Temp
Receptuur 1:	R00003	Hazelnut Chocolate Spread 2%				530.4	31-34
Receptuur 2:	R00016	White Chocolate Spread				530.4	30-35
Percentage noot:	1% HAZELNOOT	Percentage cacoa:	2.5% CACAO	Percentage melk:	3.8%		
Biologisch?	Nee	Fair Trade?	Nee	Hallal?	Nee		
Conventioneel?	Ja	UTZ?	Nee	Kosjer?	Nee		
Allergeen?	Ja	RSPO?	Ja	Speciaal?	Nee		

☐ Etiketnummer:	**E948-5 | E-TEKEN**	☐ Plaats traysticker:	Lange zijde
☐ Dop etiketnummer:	0000-0 | Geen dopetiket	☐ Pot type:	Pot 212 ml laag model/rond/deksel 66mm
☐ Codering:	3.4. EXP/ PROD	☐ Tray type:	T00006 | Tray 291x220x45 blanco (3x4 200) FSC
☐ Codering plaats:	Codering op deksel	☐ Aantal per tray	12 per tray
☐ THT:	**18 maanden**	☐ Aantal strepen:	12 strepen
☐ Deksel:	3725/18 | Deksel 66 (laag model)/plastic/wit/karton	☐ Inhoud:	200 gram
☐ Soort pallet:	WWG pallet	☐ Stapelpatroon:	Patroon 14/221 trays/13 lagen/17 trays per laag/WWG pallet
☐ Traysticker:	TS0969 | Ja, een traysticker	☐ Remarks:	

Aantal trays/dozen: **442** **Aantal per pallet:** **221** **Aantal pallets:** **2**

Productietijd gepland: **01:57** **Productielijn: 1**

Begindatum / tijd: ______ Batchcode 1e pot: ______

Einddatum / tijd: ______ Batchcode laatste pot: ______

Productietijd werkelijk: ______

Verschil tussen geplande tijd en werkelijk in min. : ______

Etiketten verwijderd van de lijn aan einde run? Ja / Nee

(Ver)storingen/opmerkingen:

Datum:	Tijd:	Code:	Duur (minuten):	Oorzaak / omschrijving:

Totaal (ver)storingen: ______

Pauze ______

Totaal ______

Weeshuis reden:	Aantal trays:
W1: Strepen slecht	
W2: Kleur wissel	
W4: Etiket	
W5: Codering	

\# tray weeshuis ______

\# tray beschikbaar ______ +

Totaal # trays geproduceerd: ______

Controle opstart/overdracht:

1. Naam + paraaf 1e lijnvoerder
2. Naam + paraaf 2e lijnvoerder

Controle aantallen:

1. Naam + paraaf Lijnvoerder
2. Naam + paraaf Stapelaar

PASTA BRUIN	
Tank	Systeem

PASTA WIT	
Tank	Systeem

# tray HF:	Productieordernummer:	Reden:

Opmerkingen / verklaring verschillen:

PLAK OP DE ACHTERZIJDE ETIKET/DOPETIKET/TRAYSTICKER EN PRINT DE CODERING

Appendix 1b- Production order operator NEW

PRODUCTIE LIJST OPERATOR

PRODUCTIE ORDER:	PR1971900694	DATUM: 31-1-2019	DAGCODE: (3119)	PRODUCTIELIJN:	1

Productietijd:

	Datum:	Tijd:
Start(datum en tijd):		

Datum:	Tijd:	Code:	Duur (minuten):	Oorzaak / omschrijving:
		Totaal (ver)storingen:		minuten

	Datum:	Tijd:	
Stop(datum en tijd):			
Werkelijke tijd order (uu:mm)			
Geplande tijd order (uu:mm)		00:34	- /-
Minder / meer tijd nodig dan gepland (uu:mm)			

Productie verliezen:

Weeshuis	
Reden	# trays
W1: Strepen slecht	
W2: Kleur wissel	
W4: Etiket	
W5: Codering	

Halffabrikaat	
Productieorder:	# trays

	Receptuur		
	Reden	# kg bruin	# kg wit
BS	Blauwe bak cat III (spoelen)		
BD	Blauwe bak cat III (doorblazen)		

New: registration of waste stream 20 and 21

Controle Productie order:

Werkelijk # gereed product (# trays)	
Geplande # gereed product (# trays)	
Meer / minder # trays dan gepland	

Indien er minder trays gereed product zijn produceerd dan gepland bij een "niet minder" of " exacte" order, geef dan aan wat de oorzaak hiervan is en hoe het tekort wordt aangevuld:

Oorzaak:
Hoe aangevuld:

Controle Productielijst (stapelaar)	
Naam:	Paraaf:

Aftekenen Productielijst (operator)	
Naam:	Paraaf:

Appendix 1c- Production order ‘stapelaar’

PRODUCTIE LIJST STAPELAAR

PRODUCTIE ORDER: PR1871809103.001 **DATUM:** 04/02/2019 (03519)

VERKOOP ORDER:	**VOORRAAD**
KLANT:	**Muscat**
ARTIKEL: 3632288-4	Nusica Hazelnut/Milk Duo Spread RSPO-SG 12/200

Artikelgegevens:

						Aantal kg	Temp
Receptuur 1:	R00003	Hazelnut Chocolate Spread 2%				530.4	31-34
Receptuur 2:	R00016	White Chocolate Spread				530.4	30-35
Percentage noot:	1% HAZELNOOT	Percentage cacoa:	2.5% CACAO	Percentage melk:	3.8%		
Biologisch?	Nee	Fair Trade?	Nee	Hallal?	Nee		
Conventioneel?	Ja	UTZ?	Nee	Kosjer?	Nee		
Allergeen?	Ja	RSPO?	Ja	Speciaal?	Nee		

- ☐ Etiketnummer: **E948-5 | E-TEKEN**
- ☐ Dop etiketnummer: O000-0 | Geen dopetiket
- ☐ Codering: 3.4. EXP/ PROD
- ☐ Codering plaats: Codering op deksel
- ☐ THT: **18 maanden**
- ☐ Deksel: 3725/18 | Deksel 66 (laag model)/plastic/wit/karton
- ☐ Soort pallet: WWG pallet
- ☐ Traysticker: TS0969 | Ja, een traysticker
- ☐ Plaats traysticker: Lange zijde
- ☐ Pot type: Pot 212 ml laag model/rond/deksel 66mm
- ☐ Tray type: T00006 | Tray 291x220x45 blanco (3x4 200) FSC
- ☐ Aantal per tray: 12 per tray
- ☐ Aantal strepen: 12 strepen
- ☐ Inhoud: 200 gram
- ☐ Stapelpatroon: Patroon 14/221 trays/13 lagen/17 trays per laag/WWG pallet
- ☐ Remarks:

Aantal trays/dozen: 442 **Aantal per pallet: 221** **Aantal pallets: 2**

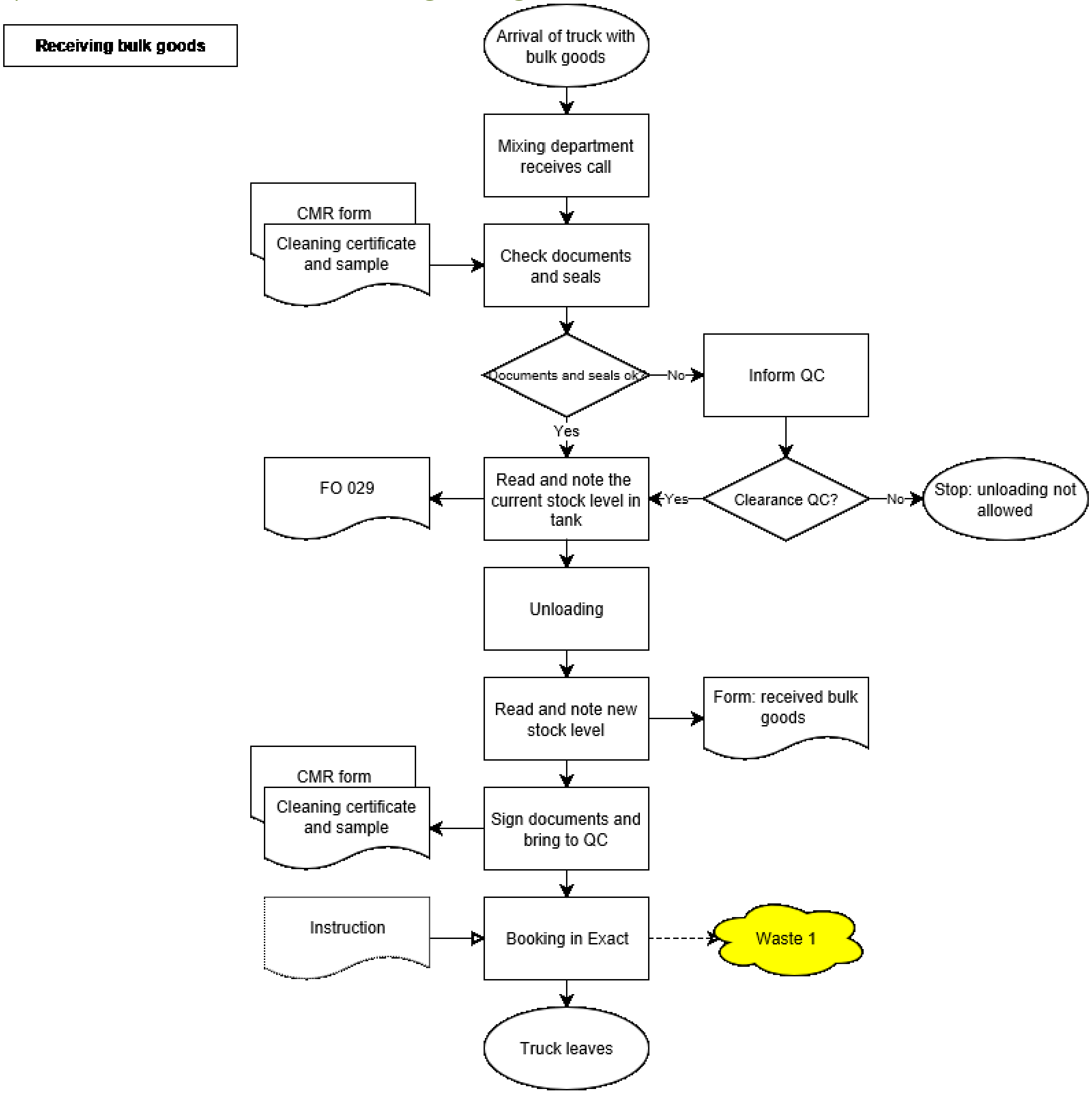
Begintijd: Datum:

Pallet :	Aantal:	Naam:	Eind tijd:	Monster instructie	Check
1	221			2x 1e laag / 2x bovenste laag	☐
2	221			2x bovenste laag	☐

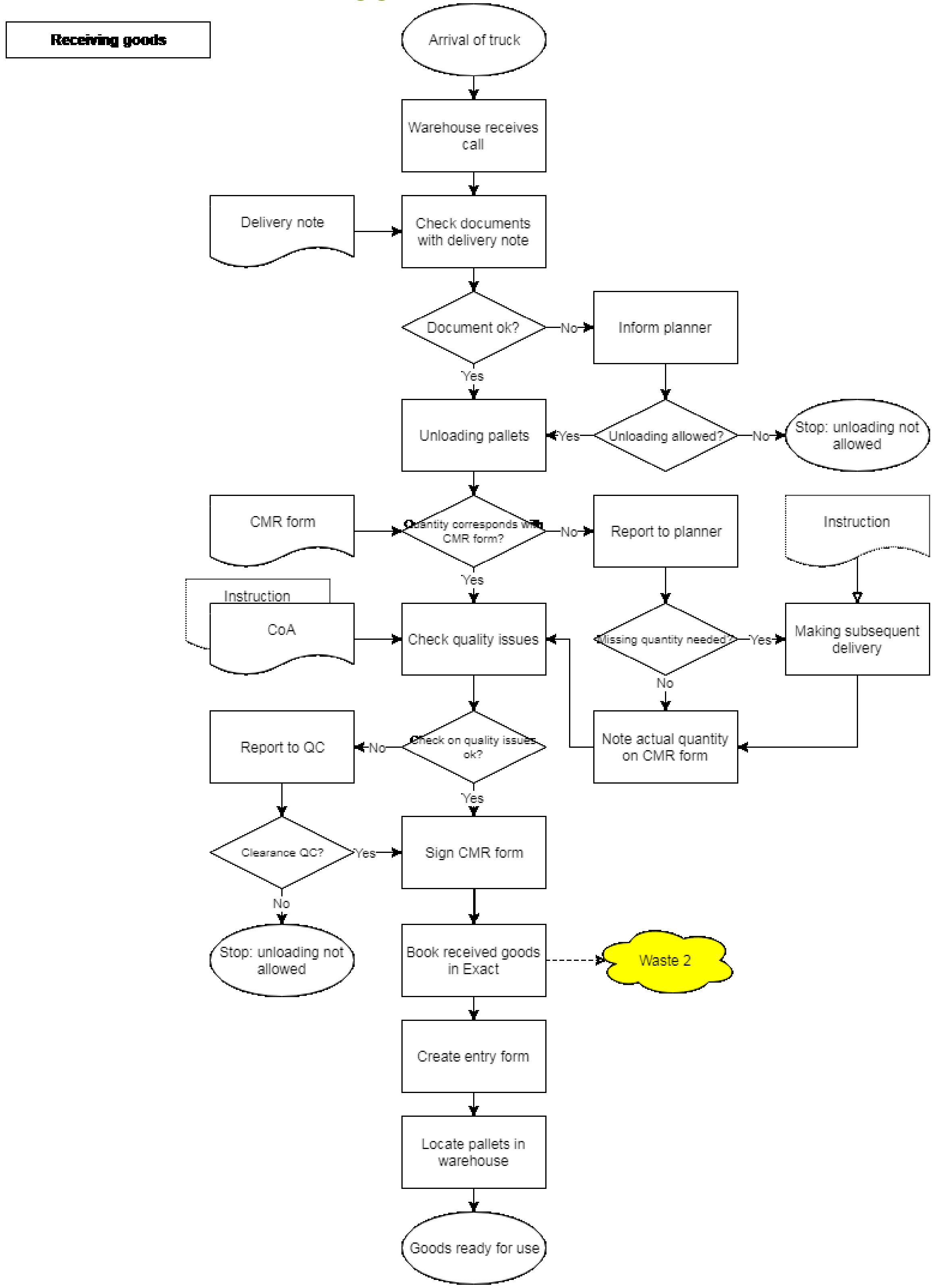
Used to determine the number of samples taken (waste stream 16)

LET OP de laatste 2 potten van de run weg zetten, dit zijn samples voor kwaliteit !!!

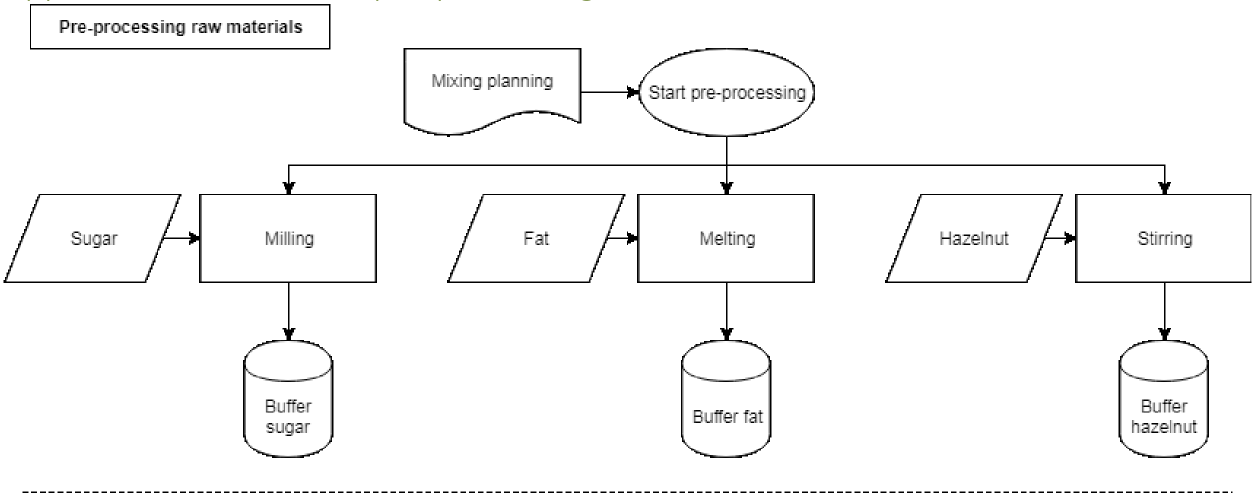
Appendix 2a- Flow chart receiving bulk goods



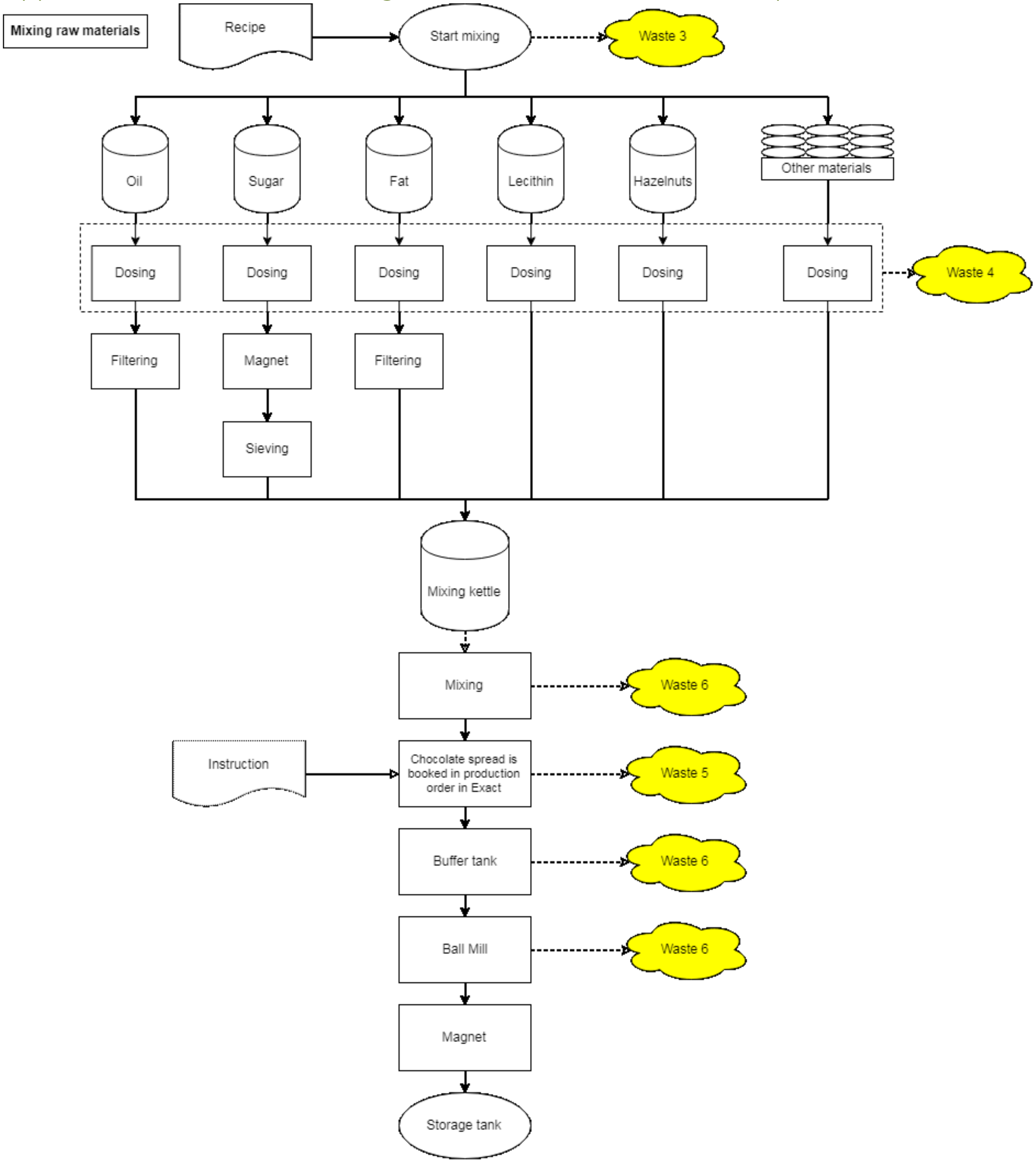
Appendix 2b- Flow chart receiving goods



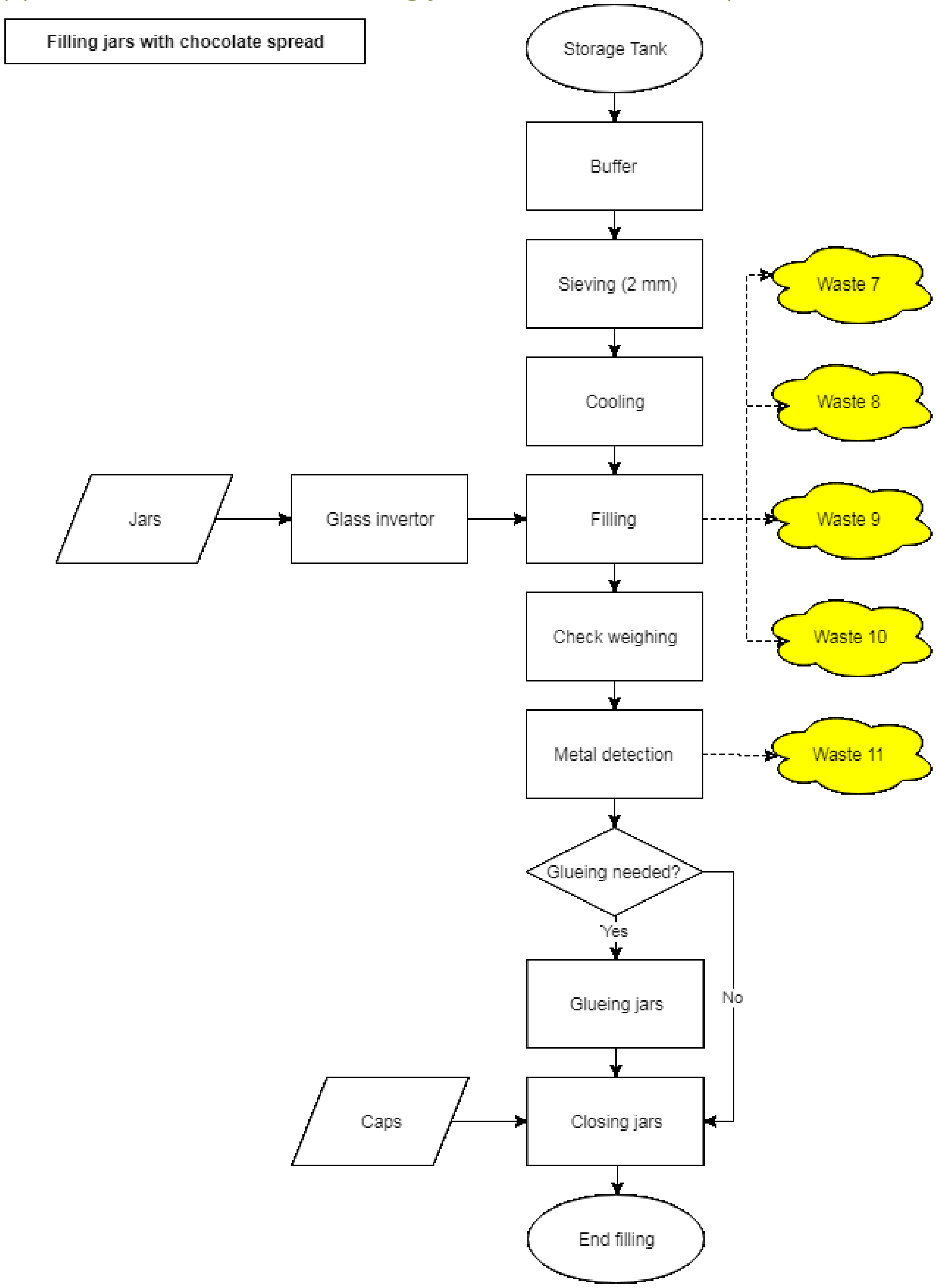
Appendix 2c- Flow chart pre-processing raw materials



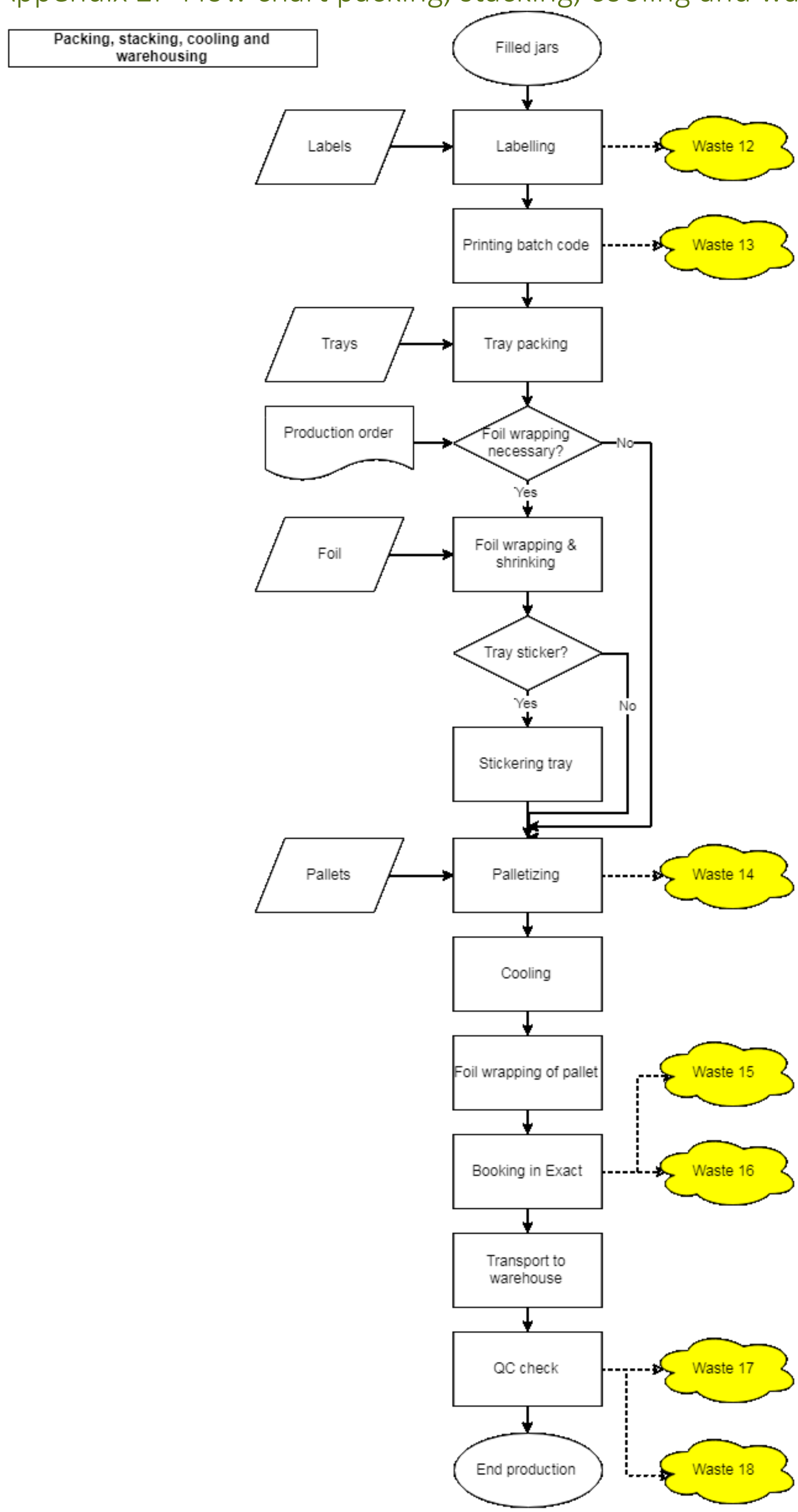
Appendix 2d- Flow chart mixing raw materials into chocolate spread



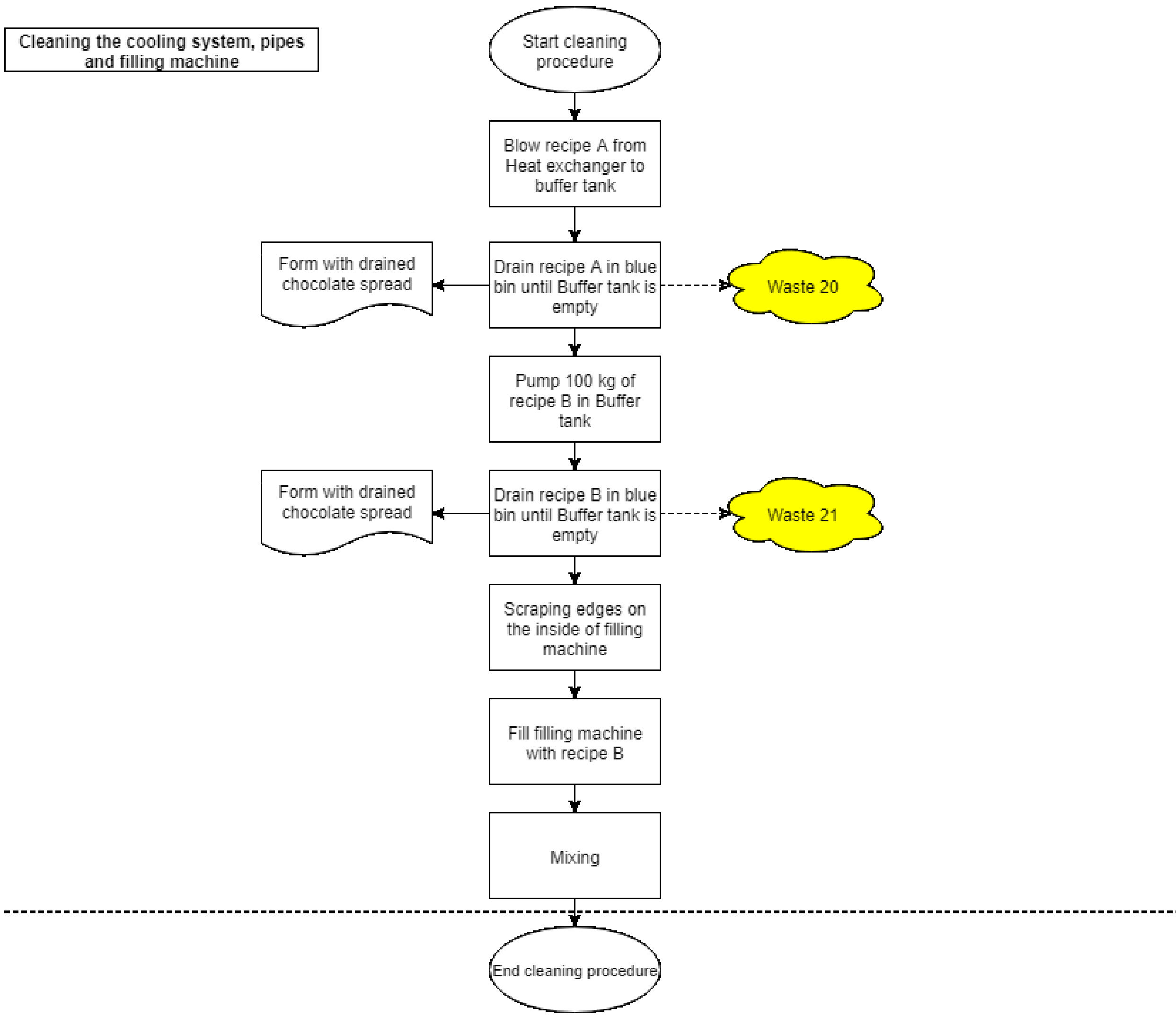
Appendix 2e- Flow chart filling jars with chocolate spread



Appendix 2f- Flow chart packing, stacking, cooling and warehousing



Appendix 2g- Flow chart cleaning procedure in changeover in the filling department



Appendix 3- Form for receiving bulk goods

	ONTVANGSTLIJST BULKLEVERINGEN	1

Bestel Nr.	Leverdatum + tijd	Grondstof	Totaal geleverde hoeveelheid (kg)	Opgeslagen in tank + nr. en/of cubitainer / suikersilo	Batch nr.	Nog aanwezig in tank/silo (liters / kg)	Aanwezig in tank/silo na inname (liters / kg)	Controle verzegeling		Reinigings-certificaat	Aftekening		
								Zegelnummers	Zegel juist en intact bij levering?	Aanwezig en voldoet bij levering?	Menger	Chauffeur	Kenteken
									Ja / Nee*	Ja / Nee*			
									Ja / Nee*	Ja / Nee*			
									Ja / Nee*	Ja / Nee*			
									Ja / Nee*	Ja / Nee*			
									Ja / Nee*	Ja / Nee*			
									Ja / Nee*	Ja / Nee*			
Bestelregel nr. van deze grondstof	*Leverdatum en tijd dat de grondstof geleverd is*	*Volledige naam van de grondstof die geleverd is.*	*De totaal geleverde hoeveelheid (tank + cubitainers) van de vrachtbrief.*	*Hier kun je opslag aangeven. Je kan door 2 regels te gebruiken, 2 opslagmethodes aangeven.*	*Batchnr. = Suiker; los datum Olie= zie CoA; batch referentie of laadorder*	*Hoeveelheid in tank/silo afgelezen van HMI of niveaumeter.*	*Hoeveelheid in tank/silo afgelezen van HMI of niveaumeter.*	*Vermeld het nummer van de zegels.*	*Controleer of het zegel intact is bij ontvangst. En of het nr. overeenkomt met het nummer op de vrachtbrief.*	*Controleer of het op het certificaat vermelde tank nr. overeenkomt met het tank nr. op de vrachtbrief*	*Paraaf menger*	*Paraaf chauffeur*	*Kenteken van de auto van de chauffeur*

** = doorhalen wat niet van toepassing is.*

21-2-2018	Versie nummer: 5	Code: FO 029	Paraaf:

F:\Appl\DATA\Total Quality System\Kwaliteitsysteem BRC_IFS\H18. Ontvangst van goederen en opslag, eindcontrole\ H18 - t FO 029.05 ontvangstlijst bulkleveringen.docx

Appendix 4- Waste registration form

Registratieformulier van afval van receptuur TIJDELIJK! (alleen voorkant invullen)

- Graag voor elke productieorder een nieuw formulier pakken en deze invullen.
- Stop aan het eind van de productieorder, dit formulier (na invullen) in de map 'Afval Daphne'.
- Recept B is van deze productieorder. Recept A is van de vorige productieorder. Vul aan het einde van de productieorder van Recept A, de hoeveelheid doorgeblazen Recept A in op dit formulier.

Algemene informatie:					
Productieorder nummer:	……………………				
Datum (van invullen formulier):	………………….				
Productielijn (1 of 2)	………………….				
Van Recept A = Vorige productieorder	Vul receptnummer in		Naar Recept B = Huidige productieorder	Vul receptnummer in	
	Wit	Bruin		Wit	Bruin
	………..	…………….		……….	…………..

Spoeling:					
Recept A (vorige productieorder):			**Recept B (huidige productieorder)**		
1.Afgetapt Recept A in blauwe bak:	#kg wit	#kg bruin	1.Afgetapt Recept B in blauwe bak (spoelpasta)	#kg wit	#kg bruin
	…………	…………….		………..	…………….
2. Retour Recept A naar voorraadtank	Recept nummer in de retourtank?		2.Retour Recept B naar voorraadtank	Recept nummer in de retourtank?	
	Wit	Bruin		Wit	Bruin
	………….	…………		………….	………….
	# kg wit	# kg bruin		# kg wit	# kg bruin
	………….	…………….		………….	…………….
3.Bij niet doorblazen en niet spoelen, maar wel met Recept B circuleren, maken wij de afspraak dat de ong. 90 kg Recept A in Recept B wordt vermengd.	# kg wit	# kg bruin			
	………….	…………….			

Grijze bak, alleen wegen bij: opstart van de productie (= start van een nieuwe productieorder). 1. Zorg dat de grijze bak leeg is voordat afval van de opstart van de productieorder hierin gegooid wordt. 2. Bak vol? Tarreer de blauwe bak met de weegschaal van de palletwagen, zodat deze op 0 kg staat. 3. Gooi de grijze bak met afval van opstart van de productie leeg in de blauwe bak. 4. Schrijf het nieuwe gewicht van de blauwe bak hieronder op (= totale gewicht grijze bak)			
Gewicht (in kg) per keer dat de grijze bak is leeggegooid (totaal van glas en pasta)			
………..	………..	………..	………..

In te vullen door Daphne:

(Samenvoegen van beschikbare gegevens voor een compleet overzicht van afval per productieorder)

Nominaal / e gewicht → Gemiddelde gewicht: ………..gram (uit lijst gewichten halen)

Weeshuis:	**# trays**
W1: Strepen slecht:	
W2: Kleur wissel:	
W4: Etiket:	
W5: Codering:	

Overig	**# potjes**
Samples:	
Metaal:	

Totaal	**# trays**
Halffabrikaat:	
Werkelijk gereed product (zonder weeshuis):	
Gepland gereed product:	

Recept B (deze productieorder	**# kg**
Totaal # ingeboekt in mengerij:	
Totaal # afval	
Totaal # afgevuld:	
Onverklaarbaar # afval:	

-

Vermoedelijke oorzaak:	

Samenvatting Afval productieorder (recept A + recept B) (uit Excel halen, na invoeren alle gegevens)	**# kg**
Opstart productie (grijze bak):	
Samples:	
Metaal:	
Meer afgevuld dan ingeboekt (bijv. bij nominale gewichten):	
Recept A aftappen na doorblazen:	
Recept A retour naar voorraadtank	
Recept A circuleren met Recept B	
Recept B afgetapt na spoelen:	
Recept B retour naar voorraadtank:	
Weeshuis: Strepen slecht:	
Weeshuis: Kleur wissel:	
Weeshuis: Etiket:	
Weeshuis: Codering:	
Totaal afval Recept A	
Totaal afval Recept B	
Totaal afval deze productieorder	

+

Gegevens overnemen van productieorder

Appendix 5 – Ratio of chocolate spread and glass in containers

Weight of empty jar (grams)	Weight of chocolate spread (grams)	Assumed weight of chocolate spread in grey container per jar (grams)	Ratio of chocolate spread in grey containers
130	200	100	0.43 (= 100/ (130 + 100))
157	270	135	0.46 (= 135/ (157 + 135))
200	300	150	0.43 (= 150/ (200 + 150))
200	350	175	0.47 (= 200/ (200 + 175))
200	400	200	0.50 (= 200/ (200 + 200))
303	750	375	0.55 (= 375/ (303 + 375))

Appendix 6- Brainstorm session on solutions

Description	Remarks	Action?
New filling machines with robot that rinses the filling machine	Expensive, not realistic on short term, but expected to reduce waste.	Work out solution
System that separates jars from chocolate spread after filling, chocolate spread can then return to the tank where it is circulated, so that the two colors are mixed	Solution takes extra time, extra space in filling department is needed.	No: does not meet requirement 1
Invest in extra filling machines, so there is time to clean them in between.	Not enough space in the filling department.	No: does not meet requirement 4
Customers must buy larger batches.	This is one of Brinkers Key success factor. We cannot change this.	No: does not meet requirement 2
Less different recipes.	This is one of Brinkers Key success factor. We cannot change this.	No: does not meet requirement 2
Static mixer in filling tubes.	Expected to reduce waste.	Work out solution
Clean the filling machine in between a product switch	Prevents the waste stream to occur, but not feasible due the time this takes.	No: does not meet requirement 1
Buy extra parts for the filling machine, such as filling tubes and pistons. After producing a batch, these parts with 'old' chocolate spread can then be exchanged with clean parts, before producing a new batch.	Takes a lot of extra time, much chocolate spread remains behind in the housing and filling machine itself.	No: does not meet requirement 1 and: not expected to reduce waste much
Invest in a dishwasher which cleans (and dries)parts of the filling machine very fast, so that parts can be replaced in between a product switch.	Takes extra time, much chocolate spread remains behind in the housing and filling machine itself.	No: does not meet requirement 1 and: not expected to reduce waste much
Rinse system and filling machine with oil. (Reuse oil afterwards)	Creates a new waste stream: chocolate spread containing too much oil. This is not desired.	No: does not contribute to the goal of this research
Planning: when chocolate spreads must be produced with a big difference in cacao percentage (so a big color difference), make sure a duo chocolate spread is planned in between, so that there is time to clean the filling machine in between.	Is already taken into account when possible. Not always possible due to rush orders.	No: does not meet requirement 1.
Create manuals on cleaning procedures in between product switches. From example: from product A, to product B: rinse x kilograms of Recipe B in the tank. Circulate this for X minutes with X pressure. Repeat this x times.	Creating this manual takes a lot of time because there are 200 recipes and the exact cleaning procedure depends on the specific product switch. In addition, it is not	No: does not contribute to the goal of this research, reducing waste

	expected that this will affect the amount of waste that is generated	
Create manuals / photos when a product goes to the food bank and when its quality still meets customer specifications. Can be customer specific.	Difficult to estimate how much this will reduce waste, but it is desirable to make this assessment of quality subjective instead of objective.	Work out solution
Steam device that cleans filling machine.	Not feasible. Takes extra time because the filling machine can not contain any water when producing	No: does not meet requirement 1 and: not expected to reduce waste much
Invest in a biodigester		Not favorable according to Lansink's Ladder

So much better in chocolate spreads...