TURNING WASTE INTO VALUE

SUITABILITY OF NEW RAW MATERIALS, AND CHOICE OF LOCALIZATION FOR PRODUCTION OF BORREGAARD'S NEW PRODUCT "SPECIAL".

FRA AVFALL TIL VERDI

NYE, EGNEDE RÅVARER OG LOKALISERING AV PRODUKSJON FOR BORREGAARDS NYE PRODUKT "SPECIAL".

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Abstract

More and more companies around the world are seeking to utilize waste to make new products. The development is important for the environment, but also a way of making value and profit.

Borregaard Industries aims to turn waste into value, and have developed a process for using raw materials from fruit and vegetable waste instead of wood, to produce a special cellulose product called “Special”. In order to do this, a mapping of possible raw materials is needed to find the best suited raw materials that will give the highest outputs. The suitability is determined by the raw materials’ chemical composition. Second, a location for the production facility needs to be found. The preferable location is determined by several raw materials’ availability and volume, and the location of these. Proximity to markets and the given location’s political, technological, social and economic profile will all affect the choice of location as well. Localization theories are discussed and used in order to determine the preferable location for Borregaard’s production facility.

The presented research is based on qualitative secondary data collected and analyzed to find suitable raw materials. Both qualitative and quantitative data on waste volumes and location have been analyzed and compared in order to find answers to this study’s location questions.

Analysis of chemical composition indicates that there are several raw materials, which will fit the production process and give good outputs. High cellulose content is always preferred and maize-, apple-, sugar cane-, wheat- and rice waste will give good results. Which raw materials that suit the process best also depends on if the raw material is preprocessed first. If it’s preprocessed, waste from maize, banana, lemon, grapefruit and orange will give high outputs.

Given a set of location factors Germany seems to be the preferable country to place the production. Borregaard also have other production facilities in Germany and therefore have knowledge of startups and operation of production here, which minimizes the risk of failure. The study showed that Brazil is the second preferred location to Germany, to place a production of “Special”.

Sammendrag

Flere og flere selskaper i verden søker å kunne utnytte avfall til å lage nye produkter. Dette er en viktig utvikling for miljøet, men også en god måte for å skape verdi og profitt.

Borregaard Industrier har nettopp et slikt mål om å skape verdi av avfall. De har utviklet en prosess som benytter frukt og vegetabilsk avfall istedenfor bruk av trær, for å produsere et produkt av spesialcellulose kalt "Special". For å kunne skape verdi av dette, må de best egnede råvarene kartlegges. Egnetheten bestemmes av råvarens kjemiske sammensetning, i forhold til prosessbarhet og output. I tillegg til egnede råvarer må lokalisering av produksjonen bestemmes. Foretrukket lokalisering påvirkes av råvarenes tilgjengelighet og volum, samt hvor disse råvarekildene er lokalisert. Nærhet til markeder og den gitte lokaliseringens politiske, teknologiske, sosiale og økonomiske profil vil også påvirke lokaliseringsvalget. Teorier omkring lokalisering har blitt tatt i bruk og diskutert for å avgjøre hvor Borregaards produksjonsanlegg bør plasseres.

Studiet er basert på kvalitative, sekundære data som er samlet inn og analysert for å finne egnede råvarer. Både kvalitative og kvantitative data på avfallsvolumer og lokalisering er også analysert og sammenlignet for å komme frem til en besvarelse av studiets lokaliseringsspørsmål.

Høyt celluloseinnhold vil alltid være foretrukket, og analysene av kjemisk sammensetning tilsier at det er flere råvarer som vil passe den aktuelle prosessen og gi gode sluttprodukter. Avfall fra mais, eple, sukkerrør, hvete eller ris vil gi gode resultater. Hvilke råvarer som passer prosessen best avhenger også av om applikasjonen trenger forbehandlet råvare eller ikke. Hvis en forbehandling er nødvendig vil mais, banan, sitron, grapefrukt og appelsin gi høy effekt.

Gitt et sett av lokaliseringsfaktorer, viser Tyskland seg å være et foretrukket land å plassere produksjonen. Borregaard har fra før av andre produksjonsanlegg i Tyskland og har derfor kunnskap om oppstart og drift av produksjon her, noe som minsker risikoen for å mislykkes. Studiet viste også at Brasil er det landet etter Tyskland hvor det vil kunne lønne seg å plassere produksjonen av "Special".

Table of contents

List of tables

List of figures

1. Introduction

This thesis is written in cooperation with Borregaard Industries, a world-embracing industry with headquarter in Sarpsborg, Norway. Borregaard owns and operates the world's most advanced bio refinery. By using natural, sustainable raw materials, the company produces advanced and environmentally friendly biochemicals, biomaterials and bioethanol that can replace oil-based products (Borregaard 2011).

Our commission is to find out which raw materials that is the most suitable for production of Borregaard's new product ”Special”, based on different kind of fruit and vegetable wastes' chemical composition. To be able to decide where to produce this product, Borregaard also need to know where these types of waste occur globally, and its existing value regarding existing markets. This thesis is related to a business secret at Borregaard and therefore we temporary name the product “Special”, until they unveil it and start the production.

Today's fruit and vegetable industry produce a huge amount of organic waste from the production, preparation and consumption of food. This waste creates a lot of biomass that is a potential pollution source because of lacking treatment. The waste is contains many reusable substances of high value (Laufenberg et al. 2003), so how can organic waste be used to make profit? The suggestions are numerous, but by our opinion, few projects have been more technical and promising in this industry, than the process Borregaard hopes to implement already this year.

1.1 Purpose of the study

First and foremost, the purpose of this study is to give Borregaard and involved partner's new knowledge about reusing fruit- and vegetable waste for production of “Special”. It will also give Borregaard expertise of where the sources can be found globally and where it might be most preferable to locate their production site. EU is also doing some projects with some similarity to this and the thesis' results will probably be of much interest for them (Øvrebø 2011c).

Several studies related to chemical composition and transformation of organic waste into

value added products have been done before, and we will use these researches to build up a complete overview of chemical composition needed for this study (Heier 2011b).
Analyzing waste from fruit and vegetable production as alternative raw materials for production of "Special" is an important and interesting assignment, not only for Borregaard, but also for the global environmental interest. If it gives results showing possibilities for using such waste to new products, it will open a huge new market where waste is the key input. Hence, It will also be a cleaner and more environmental friendly way to handle this kind of waste compared to what it's used for today, because the organic residues are suitable for secondary processes, as operating supplies or as ingredients of new products (Laufenberg et al. 2003).

1.2 "Special" and its raw materials

"Special" is a product with unique properties which can be used in e.g. food-, adhesive-, pharmaceutical- and composite industry. During new product development, the product is able to meet the big health and nutrition megatrend by using low priced raw materials, like waste from the fruit and vegetable industry.

Waste from production processes involving fruit and vegetables can contain high volume of reusable substances and therefore be of high value. By using other raw materials than trees to produce "Special", it's possible to gain higher profit and make products with new applications. This will make it possible for Borregaard to reach new market segments

The waste we are mentioning during this thesis is defined as peel, pomace and residues from the fruit and vegetable industry, e.g. the fruit juice industry. Waste from these sources will be the raw material for the production of "Special".

By this research it will be possible to get better and cleaner products for use in the food industry, like e.g. fat replacement and viscosity control. Today's society's demands appropriate nutritional standards and it's a decreasing availability for raw materials. This gives an opportunity to make a clean product customized for the demands and at the same time make commercial products from organic residues. Borregaard is therefore going to have clean label as an ambition for their products.

National Starch has defined clean label as: *"Free from chemical additives; simple ingredient listing (without ingredients that sound chemical or artificial); minimally processed using traditional techniques that are understood by consumers and not perceived as being artificial"* (Halliday 2010). Borregaard also require raw materials without genetically modified backgrounds. That means organic material where genetic material not has been altered through genetic engineering methods.

1.3 Research question

The thesis will attempt to answer the key research question:

- *Which raw materials are the most suitable for production of Borregaard's product "Special", and where will it be most preferable to place the production?*

By analyzing chemical composition of waste from several fruits and vegetables, and finding where in the world the biggest volume of the waste occurs, it will be possible to answer the key research question. To ensure that we get the most correct answers as possible we have divided the key research question into three specific questions, which need to be answered in this study:

- Q1: *Which raw materials are best suited for the production?*
- Q2: *Which raw material sources are available, and where are they located?*
- Q3: *Where will it be the most preferable to place the production?*

By saying best *suitable* raw materials for the production of "Special", we mean which raw materials that will fit the production process best, and which ones that gives the best output, measured by the chemical composition of the given raw materials. (Borregaard R&D division 2011).

After suitable raw materials are determined we are looking for their location and availability. We define availability to be necessary volume for production of "Special". Necessary volume is at least 100.000 tons, dependent of the chosen raw materials chemical composition (Heier 2011a).

The last specific question, Q3, is about where to locate the production. Because of lack of time, the preferable localization of production facilities is mostly related to just raw materials' accessibility. The given time and the other limitations are discussed in the following chapter.

1.4 Limitations

Research of this type will always be done under some limitations because it will never be possible to examine all factors studying questions like this. By taking this assignment we also work under limitations set by Borregaard and their preferences. In accordance with Borregaard, we are just going to use organic waste as a raw material. We are not going to calculate the profitability of the project, just what kind of suitable raw materials and location related to raw material availability.

Given the fixed amount of time for this study we were also forced to limit the research and omit some factors and focus on the most important ones. There are several factors that's influence the last part of the research question, "*Where will it be the most preferable to place the production?"*. For instance we could have taken all the factors from *figure 4: "Determinant factors of location decisions"* into consideration, to get a more precise calculation of the best location for the production facilities. The given time is too short to do such a thorough study, because each element in the figure is a whole study itself. Therefore, we are going to determine the actual place to produce "Special", mostly by the raw material availability, evaluated of a combination of volume and processing suitability. The theories presented in the theoretical background will be used in order to consider the most important localization factors for this given cause and time.

The authors are also lacking necessary chemical background to do an adequate analyze of the scientific reports the chemical composition are based on. Hence, the chemical issues have been communicated to specialists at Borregaard. If we had the sufficient chemical knowledge and enough time, we would appraise to test the raw materials by ourselves, instead of using secondary data. The advantage to do own testing is a single analyzing method for all raw materials, hence more accurate data for the purpose.

1.5 Structure of the report

The report of this study contains four main sections that consist of a number of linkages. First the theoretical aspect regarding determinant location factors and challenges are presented in chapter 2 to give a short brief of the theories. Chapter 3 is explaining the methodology of the research that includes research design during the report, how the data is collected and analyzed and choices of theory. The quality of data is also evaluated. Chapter 4 is presenting the actual findings of the study. This is the chapter were all the datasets and discoveries of the raw materials' waste volume and chemical- composition and properties are disclosed. Chapter 5 will attach the findings with the theoretical view and present a discussion of our considerations of the combination. Finally, in chapter 6 we will provide a conclusion of the study and also give some recommendations for further research.

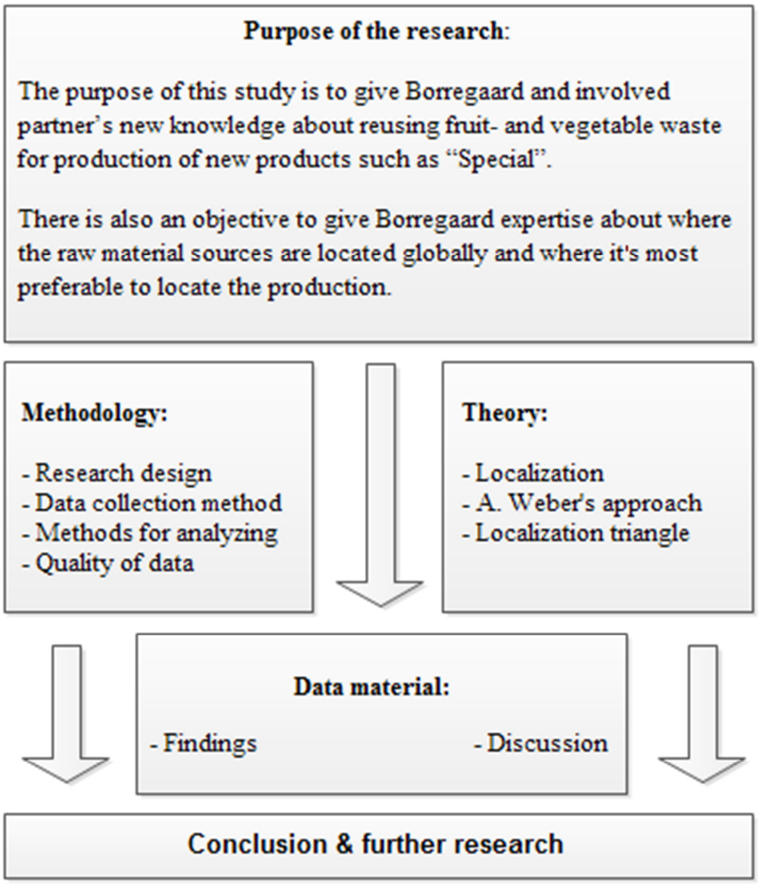


Figure 1: Structure of the report (Rostad & Larsen 2011)

2. Theoretical background

In order to be able to answer the research question of this study, especially the third specific question (Q3), a study of relevant theories is needed. This section will present the relevant theoretical approaches of location theories to substantiate the placing of a firm's production facilities. Central to this literature study is to determine factors that contribute to define Borregaard's most preferable place for production of "Special".

2.1 What is location?

"We're not lost. We're locationally challenged."

(Ford J.M.)

The choice of location is often a big challenge, and can make the difference between failure and success (Arauzo-Carod & Manjón-Antolín 2007). Therefore it is essential that firms do thorough analysis of where their activities should be located. It's always various reasons why public and private facilities locate themselves the way they do, exactly where to locate is therefore one of the most critical decisions an entrepreneur need to take (Arauzo-Carod & Manjón-Antolín 2007).

It's appropriate to have a clear definition of the term "location theory". For this thesis we will be using Ragnar Nordgreens definition: "*The term "location theory" implies theories aiming to explain how industrial activity is localized*" (Nordgreen 1999).

There are several aspects that affect the industrial location. The question of where a firm will locate therefore becomes a question of which location will maximize the firms' profits (McCann 2001). Firstly, the supply of relevant resources and the ability to exploit them effectively depends on where the activities are executed. Second, because there may be substantial costs and obstacles associated with transporting goods. A third reason is that the ability to upgrade and develop their own resources may depend on how the activities are located (Kubberud 2000). All this is related to the alternative cost, which means the value of alternative you lose by choosing another location or activity (Nordgreen 1999). Making a choice of location is a time consuming- and complex process that involves finding a balance between various considerations. It's appropriate to do analysis and research to find the most suitable location where the industry can gain first rate outcome and advantages, because territorial matters do matter.

2.2 Localization theories

As early as 1826 the first publication about location theory was issued. The article was about the localization problems in the agricultural industry, made by J.H. von Thünen. In the following years, there have been several theorists who have evolved the theory based on Thünen's work. The most significant of the theorists was Alfred Weber, who published his first book about localization in Germany in 1909 (Kubberud 2000).

2.2.1 Alfred Weber's theoretical approach

Weber's goal was to identify the optimal place to localize an industry. According to Weber, there will be appropriate to assume that the firms' aim is to maximize its profit. Based on this assumption, Weber created a list existing of three main factors that influence the industrial location (Kubberud 2000):

- Transport costs
- Labour costs
- Agglomeration economies

Weber is also clearly attentive to other factors that influence the perfect spot of location. These are mainly basic costs like running costs, tied-up capital, raw material costs, tariff rates and other costs (Nordgreen 1999).

Figure 2 shows the relation between basic costs and localizing costs. The basic costs doesn't change due to the location, they need to be paid independent without regard to territory. If we assume that the quantity doesn't change graphically, the figure will show the relation between total revenues and costs.

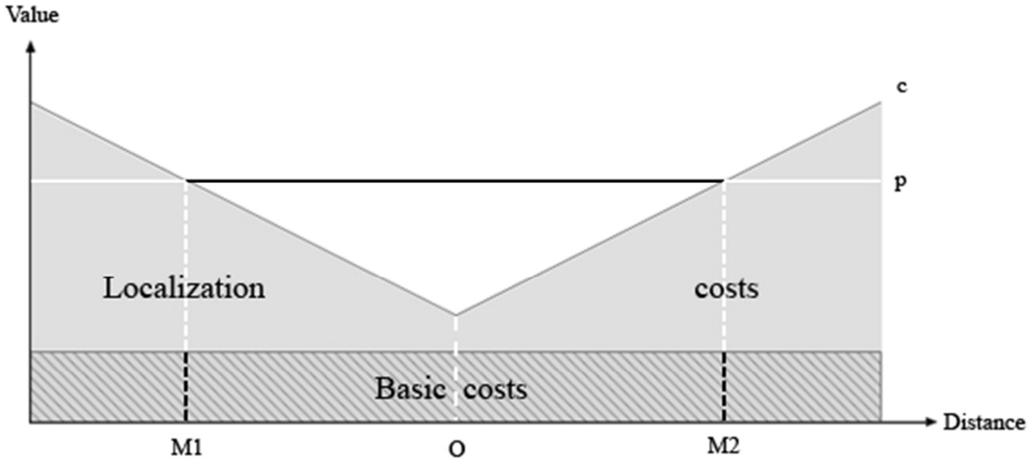


Figure 2: Basic costs & localization costs (Nordgreen 1999: 26)

The c-curve will show the total costs and not the costs pr. unit. Point O illustrates where the total profit is highest. The localization costs vary from location to location, it's especially production factors like raw material costs and labour costs (Nordgreen 1999).

2.2.2 Transport costs

Weber considered the transportation costs as the primary variable for industrial location. The transport costs affect the optimal location of production activities. The industry wants to localize were the amount of transport costs is lowest and the transport costs is mainly calculated by weight and distance (Nordgreen, 1999). The main objective is to minimize the costs by gathering together the necessary input factors and transport the finished products to market. Heavy raw materials, or those that were reduced in weight during the production process, would tend to pull the production facilities towards the input factors and opposite. If the finished product weights less than the raw materials, the savings associated with transportation will obviously increase, the closer the production is it to the source. A good example is Kubberud's case on cement production. Cement factories are mainly located near the limestone quarry. The reason is it that limestone is reduced by 45 % by weight after burning. Afterwards the consumer mix the cement with a heavy cheap gravel to make concrete, the gravel can be found almost everywhere. The concrete is considerable heavier after mixing, which logically makes a preferable location for the mixing process close to the market (Kubberud 2000).

2.2.3 Labour costs

Assuming the Webers profit-maximizing approach for the firm, to locate where the factor costs are lowest, applies also highly to labour costs. The labour level in Norway is considered as fairly the same, independent of where we are located. The labour in Norway is organized in national wide organizations and the wage agreements have largely been nationally coordinated. Across national boundaries and especially between continents there are bigger differences (Nordgreen 1999). The labour costs between Europe and for instance Asia is considerably different. For example, China has for the last decade attracted companies from the entire world because of its inexpensive labour costs. Due to low-priced labour costs, several industries have relocated the production to new countries or areas. In some instances it has been the right strategy, but sometimes it also fails. Meeting with a new country has been a costly affair for some industries. The host country has not always the same infrastructure and formalities as the home country, so the calculated savings through lower labour costs will be minimized by poorly supply and information lines. The geographical dimension is not absent when it comes to differences in labour costs, it can be decisive for the choice of location, but it is appropriate to evaluate all factors to avoid unforeseen occurrences (Nordgreen 1999).

2.2.4 Agglomeration economies

Agglomeration economies is the advantage a company achieve when it localize in a cluster connection with other companies (Nordgreen 1999). Clusters are local networks with an aggregation of cooperating firms, where information and competence are flowing between them. Industrial clusters are highly relevant to the discussion of localization, because the phenomenon itself is largely a result of firms' location decisions. The favorable economic effects are called agglomeration benefits, for instance infrastructure, technological spillovers, transport and cost sharing (Kubberud 2000).

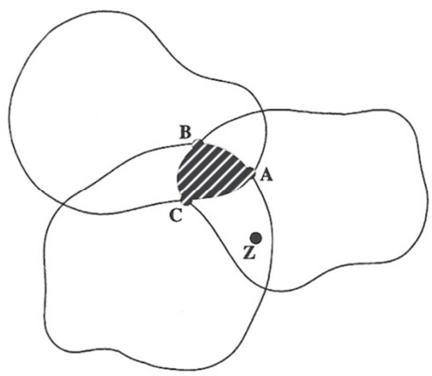


Figure 3: Agglomeration (Nordgreen 1999: 38)

Figure 3 illustrates the shaded area where industry A, B and C obtain agglomeration advantages. Z is an industry located out of the cluster area. Z is close to A and C, but not to B. B will not join the localization of Z if not A and C covers the financial loss.

When there exists such an area where all (A, B & C) obtain agglomeration benefits is it rarely relevant for two of the companies to cover localization loss for the third company which is located outside of this area. Z is therefore irrelevant for this cluster (Nordgreen 1999).

The most principal upgrading mechanism is external economies of scale. In external economies companies take advantage of the location by collaborating with other companies in proximity, which results in cost advantages. Some clusters develop specialized education and research directed to the dominant local industry, and establishes norms and conventions that stimulate to collaboration between the companies. The point is that companies achieve a number of free benefits by being located together with other similar businesses, as businesses outside these areas cannot obtain (Schilling 2010).

Another characteristic of industrial clusters is also high innovation pressure. The pressure is caused by the combination of demanding and advanced customers and intense competition to get them. By locating the business in an industry cluster, the firm will increase their frequent product and process innovations, which can result in large profitability gains in their markets. Companies which are exposed to international competition cannot stay outside an industrial cluster. The competence development and the innovation in the industry and commerce, increasingly happens inside clusters. It’s essential to be located in the strongest competence cluster, and preferably attend to shape it together with other strong actors to gain more competitive advantage than your competitors (Kubberud 2000).

2.2.5 Other determinant factors of location

"Economic activity tends to be geographically concentrated" (Arauzo-Carod & Manjón-Antolín 2007). This makes some areas more preferable than others for establishment of a new industry, like different countries, cities, regions and metropolitan areas. There exist several factors additional to Webers three main factors that play a role in localizing decision making. Traditional factors for choice of localization in Norway has been nearness to energy sources, raw materials and transport terminals (Kubberud 2000).

Figure 4 shows a list of some of the most determinant factors that need to be considered when choosing a location.

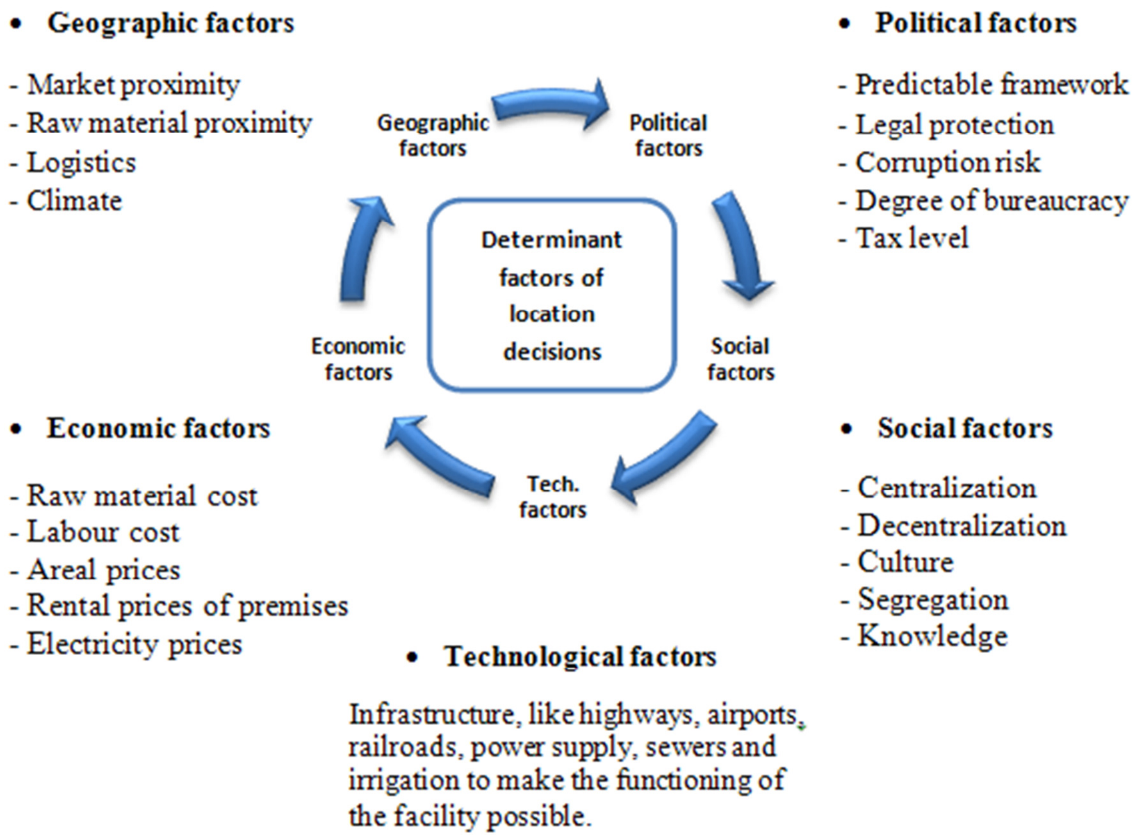
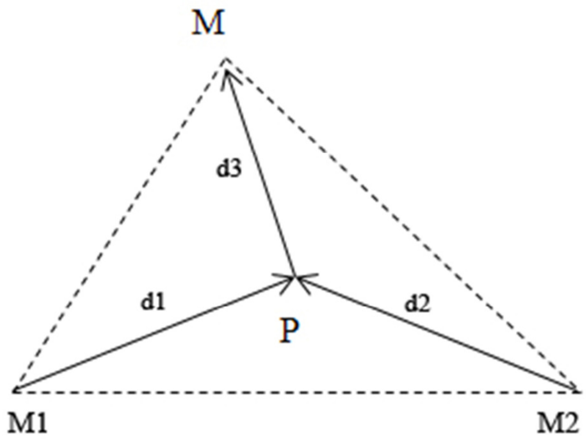


Figure 4: Determinant factors of location decisions (Rostad & Larsen 2011)

2.2.6 The weber location-production triangle

In this section we want to illustrate some practical examples of location challenges, and how the location decision affect the transport rates of input and output goods to an industry. Alfred Weber has from the German mathematician Laundhart developed the two dimensional "localization triangle". The triangle is often described as Weber location-production triangle, where the industry uses two raw materials to produce one output (McCann 2001).



M_1, M_2	=	Raw material sources
M	=	Market
P	=	Location of the firm
d1, d2, d3	=	Transport distances

Figure 5: Localization triangle (McCann 2001: 8)

Figure 5 illustrates a localization of a market M, and two raw material sources M_1 and M_2, where none of the raw materials are dominant. The localization of the production P will depend on the quantity consumption of raw material from M_1 and M_2, and their weight and distance.

It's necessary to take some assumptions in order to use Webers theory. We need to assume that the input production factors of labour are available everywhere, hence the prices and quality of labour are therefore not varying dependent of location. The same is relevant to rental prices of land, but there is no reason to assume that the prices of labour, capital and land are equal to each other in the reality (McCann 2001).

When the industry is able to locate anywhere, it's apparently that the industry will locate where it will be able to maximize its profits. The determinant factor to earn maximum profits is dependent of the distance of any fixed location from the input sources (M_1, M_2) and output market point (M). Deciding the industry's optimal location involves analyzing the relative total input plus output transport costs at each location, because the different locations of the firm will create significant variations of transporting costs (McCann 2001). In order to explain Webers location triangle, we will short demonstrate some hypothetical examples adopted from Philip McCann's book, Urban and Regional Economics.

2.2.7 The location and input transport costs

Consider *figure 5* as an illustration of a car industry (P) and its market (M) and suppliers (M_1 and M_2). This approach has two raw material sources to the car production, steel (input 1) from M_1 and plastic (input 2) from M_2. Let us imagine that a completed car weighing 2 tons, 1 ton of steel and 1 ton of plastic, where the transport rate for steel is one half of the plastic transport rate. The weight and transport costs are determinant factors who decide where the location of the firm is most cost effective. In this case the industry has to locate closer to M_2 where the plastic production takes place, by reducing the value of d_2 relative to d_1. There is also relevant to imagine different production functions. If the car weighing 2 tons from 1,5 tons of steel and 0,5 tons of plastic, the transport costs of steel will be increasingly higher, despite the plastic is twice as expensive to ship per kilometer as steel. The optimal location of the industry based on the new production function will undoubtedly be closer to the steel input M_1 (McCann 2001).

This framework makes it possible to compare the effects of different locations of the industry. It is feasible to set up two competing car producers in the same model, where one is relatively plastic intensive and one is relatively steel intensive. Let us use the two production functions as above, where industry A is using the plastic intensive production function and the industry B use the steel production function. As the *figure 6* illustrates, the industry A will locate as close possible to the plastic source M_2, and industry B will strive to locate relatively close to M_1, the source of steel. For example, Industry A's total transport costs will be dominated of plastic

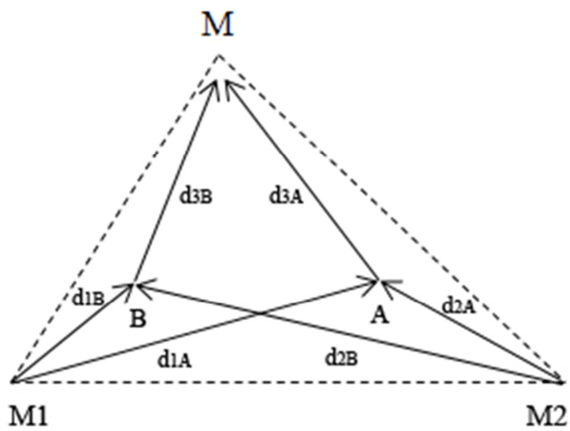


Figure 6: Competing industries, same input sources (McCann 2001: 10)

transportation, because plastic is the most expensive material to carry in A's production function. There will be appropriate to reduce the higher costs associated with plastic shipments by reducing d_{2A} and increasing d_{1A}. In the case of industry B, they will be working to reduce d_{1B} and increase d_{2B} to be most profitably (McCann 2001).

2.2.8 The location and output transport costs

The main costs of an industry output is generally transport costs depending of the deliveries' weight and volume. In this case we have a situation where comparable industries have different locations regarding to the market, where the mass of the product changes through the manufacture process. Variations in weight and bulk will influence the optimum location related to the market, input- and output factors (McCann 2001).

The *figure 7* shows two automotive manufacturers, A and B, are producing indistinguishable weights of output from identical weights of raw materials, this leads to common production functions for the two industries. Let us imagine that industry A is a manufacturer of small vehicles designed for urban traffic and industry B is specialized to produce large trucks made for terrain environments. The transport costs are dependent on the bulk and weight of the input, and the input factors that have a high density will exhibit lower unit transport rates than inputs with low density. In this example industry A produces goods which are quite compact and dense compared to industry B which produce very bulky goods. These results in more expensive transportation of finished products for B than A, so industry B will therefore strive to be located as close as possible to the marked, in order to reduce the transportation costs of finished goods. The advantage for industry B is the possibility of moving faster to the market than industry A, and in addition be more market oriented (McCann 2001).

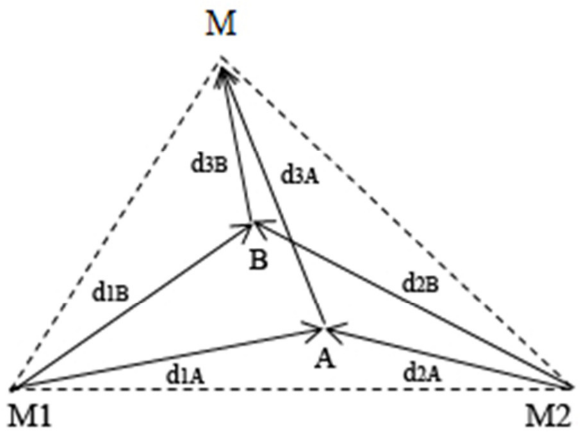


Figure 7: The location & output transport distance (McCann 2001: 12)

2.2.9 Weaknesses with Webers theory

Like all other localization theories, Webers localization theory also have some weaknesses, but survive during its explanatory power (Nordgreen 1999). The most significant weaknesses are:

- The theory is based on free competition.
- The localization triangle largely involves a degree of simplification of the real conditions.
- Transport costs are overestimated. In financial statements, transport costs are small compared with total costs. Transport costs in financial statements and budgets are often lacking important social economic transport costs like road costs and environmental damages. If these factors will be integrated, the role Weber gives the transport costs more realistic view.
- Webers theory is based on the "Economic Man" model. Everyone has complete and instantaneous information about all relevant topics and simultaneously ability to consider the information, to take decisions who results in profit maximizing. In reality the information available to firms is often rather limited.
- The theory assumes constant technology, social and economic framework. That gives a static theory in a world where exactly suchlike conditions changes fast.
- Webers theory assumes a single market place for the manufactured products, but in reality the majority will be sold to indefinitely places.
- The theory assumes that the localizing factors are absolute and impassive.

(Nordgreen 1999: 43)

The list is directly translated by the authors from Nordgreens book: "Grunnleggjande lokaliseringsteori".

3. Methodology

The key research question: "*Which raw materials are the most suitable for production of Borregaard's' product "Special", and where will it be most preferable to place the production?"* can't be answered with only theories. A large amount of research data has to be collected and analyzed to get an answer. To do this, an appropriate methodology and research design had to be chosen.

3.1 Research design

Research design is about which strategy you choose to use for the study. To assure that the goals of the thesis are reached, the design of the research is significant. This thesis is mostly based on secondary data from scientific reports, but also interviews and discussion with experts has been an important part of the research. A mix of both qualitative and quantitative data has been collected and analyzed. A lot of quantitative data was collected, but qualitative analysis and discussions with Borregaard's research department was needed, especially to find what should be the most suitable raw material. Because the project is at an early stage it's important not limiting the research using just a more narrow quantitative research design.

The scientific reports have given some data on chemical content of fruits and vegetables, but nothing of the literature compares the content of waste from various sources as adequate as needed. Borregaard is also lacking a lot of knowledge on the exact chemical composition of the raw materials they want to use, though they have a lot of knowledge in biochemistry. They are in an early stage of the project and this is something no one has done before, and it's natural not having all the knowledge yet. Anyhow Borregaard is a big company with huge amount of resources and will most likely be able to make this happen.

The research design is naturally designed with this in mind, and is divided into 2 main parts. One to find the best suited raw material for the production process (Q1), and one to find the most preferable location for the production (Q2 and Q3).

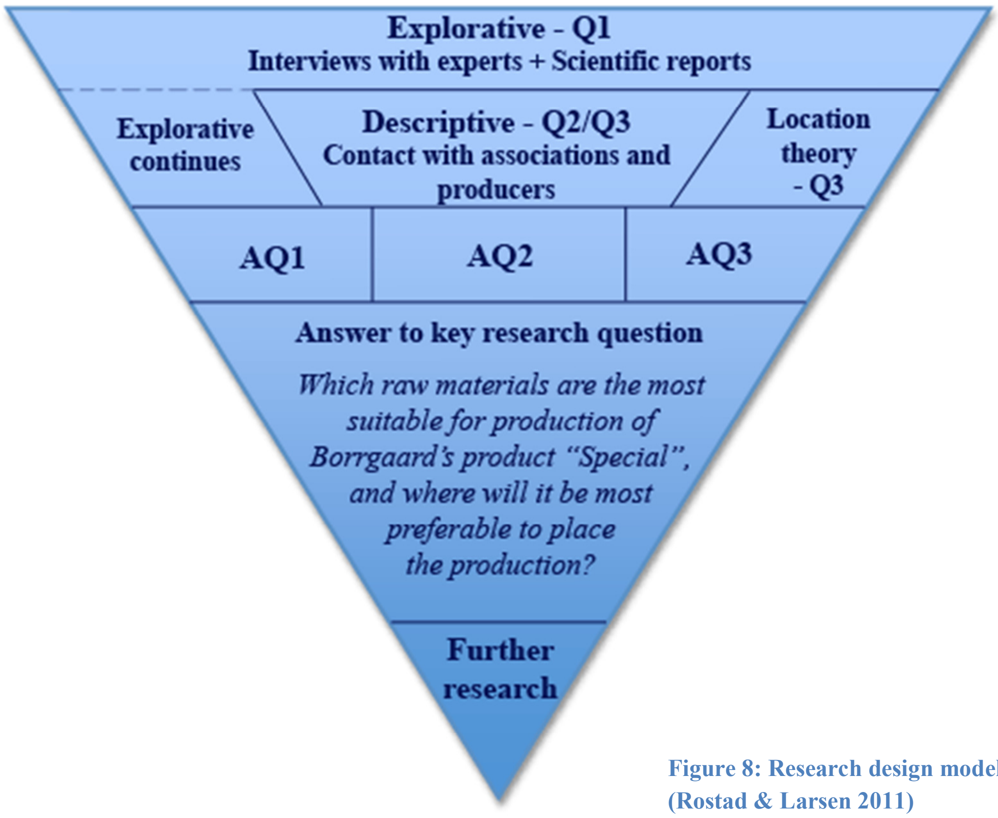


Figure 8: Research design model (Rostad & Larsen 2011)

To find the answer to the first part, explorative design was necessary because of little knowledge about the content of the raw materials and lack of earlier studies for this particular use. Using this kind of approach will also possibly give Borregaard some hypothesis and insight on which factors that needs to be tested in later research. The first part of the research consists mostly of qualitative data on chemical contents of the raw materials. The second part is a more quantitative research collecting quantitative data on amounts of waste around the world and comparing these. Some explorative research was also necessary to go on with parallel with the second part of the research in order to get more insight and answers to specific research question 1.

By doing this research using the chosen research design we were able to get the necessary data. Analyzing this data in the light of selected theory will make it possible to answer the 3 research questions and the key research question.

3.2 Data collection method

The objective of this thesis is to find the best suited raw materials for "Special", and to find approximately where it will be preferable to place the production site for this product. In order to do this, a huge amount of data had to be collected and analyzed.

The first step in our research was to get more insight in the subject and then find which raw materials that would be best suited for the production. The best way to get this insight was through reading scientific reports on chemical composition of vegetables and fruits, and discussions with Borregaard. Data was collected through a wide search at scientific journal search sites on the Internet, and through interviews and discussion with experts at Borregaard. The main part of the scientific reports was found at ScienceDirect (ScienceDirect 2011) searching for reports on for example: "*chemical content of tomato residues"* and *"Dietary fiber of soy bean straw"*. With such little previous knowledge and experience this was a time consuming task having to read through a big number of reports that didn't have the exact data we needed. We estimate that off all the reports we read and searched through, approximately only 25% of the over 220 reports were of any use for this specific study. The next table is an overview of all the 53 essential reports we used to make the spread sheet *Chemical composition of raw materials.xlsx*. All this reports are downloaded from ScienceDirect, except from no. 1. Advances in potato chemistry and technology (Singh & Kaur 2009), no. 31. Maize in human nutrition (Agriculture & Consumer Protection 1993), no. 46. Saccharification of cellulosic waste materials (Agriculture & Consumer Protection 1997), no. 47. Sorghum and Millet in African Nutrition (Blackherbals) and no. 53. Wheat straw as a Paper fiber source (The Clean Washington Center 1997).

Table 1: Overview of the 53 essential reports (Rostad & Larsen, 2011)

1.	Advances in potato chemistry and technology
2.	Assessment of pretreatments and enzymatic hydrolysis of wheat straw as a sugar source for bioprocess industry (Volynets & Dahman 2011)
3.	Barley husk and coconut shell reinforced polypropylene composites: The effect of fibre physical, chemical and surface properties (Bledzki et al. 2010)
4.	By-products from different citrus processes as a source of customized functional fibres (Marin et al. 2007)
5.	Cellulose and hemicelluloses recovery from grape stalks (Spigno et al. 2008)
6.	Cellulose, hemicelluloses, lignin and ash content of some organic materials and their suitability for use as paper pulp supplements (Ververis et al. 2007)
7.	Characterization of water yam (dioscorea alata) for existing and potential food products (Baah 2009)
8.	Compaction characteristics of barley, canola, oat and wheat straw (Adapa et al. 2009)
9.	Comparison on pore development of activated carbon produced from palm shell and coconut shell (Wan Daud & Wan Ali 2004)
10.	Delignification of rye straw using hydrogen peroxide (Sun et al. 2000)
11.	Densification characteristics of corn cobs (Kaliyan & Morey 2010)
12.	Dietary fibre components and pectin chemical features of peels during ripening in banana and

plantain varieties (Emaga et al. 2008)

13. Dietary fibre content and antioxidant activity of Manto Negro red grape (Vitis vinifera) pomace and stem (Llobera & Canellas 2007)
14. Dietary fibre form edible seaweeds: chemical structure, physicochemical properties and effects on cholesterol metabolism (Jiménez-Escrig & Sánchez-Muniz 2000)
15. Dietary fibre fractions from fruit and vegetable processing waste (Nawirska & Kwaniwska 2005)
16. Dietary fibre in sweet potatoes (Mullin et al. 1994)
17. Diffusion-processed sweet potato pulp, a new product with broad appeal (Franklin 1984)
18. Direct extraction of oil from sunflower seeds by twin-screw extruder according to an aqueous extraction process: Feasibility study and influence of operating conditions (Evon et al. 2007)
19. Effect of alkaline treatments at various temperatures on cellulose and biomass production using ubmerged sugarcane bagasse fermentation with trichoderma reesesi QM 9414 (Aiello et al. 1996)
20. Effect of irrigation and nitrogen on yield and yield components of two rapeseed cultivars (Al-Jaloud et al. 1996)
21. Effect of ozonolysis pretreatment on enzymatic digestibility of wheat and rye straw (García-Cubero et al. 2009)
22. Effect of sodium hydroxide and alkaline hydrogen peroxide treatment on physical and chemical characteristics and IVOMD of mustard straw (Mishra et al. 2000)
23. Effect of urea-treated or untreated straw with cotton seed on performances of lactating Maradi (Red Sokoto) goats in Niger (Djibrillou et al. 1998)
24. Emissions of organic compounds from the combustion of oats – a comparison with softwood pellets (Perzon 2010)
25. Ensilage of pineapple processing waste for methane generation(Rani & Nand 2004)
26. Enzymatic hydrolysis of pretreated rice straw (Vlasenko et al. 1997)
27. Extraction and fractionation of insoluble fiber from five fiber sources (Claye et al. 1996)
28. Extraction, characterization and potential applications of cellulose in corn kernels and Distillers' dried grains with solubles (DDGS) (Xu et al. 2009)
29. Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment (Figuerola et al. 2005)
30. Hydrothermal pre-treatment of rapeseed straw (Diaz et al. 2010)
31. Maize in human nutrition
32. Natural cellulose fibers from soybean straw (Reddy & Yang 2009)
33. Near-infrared analysis of the chemical composition of rice straw (Jin & Chen 2007)
34. Nutritional characterization of tomato fiber as a useful ingredient for food industry (Herrera et al. 2010)
35. Nutritional evaluation of some subtropical red and green seaweeds Part II. In vitro protein digestibility and amino acid pro®les of protein concentrates (Wong & Cheung 2001)
36. Nutritive composition of soybean by-products and nutrient digestibility of soybean pod husk (Sruamsiri & Silman 2008)
37. Parenchymal cell cellulose from sugar beet pulp: preparation and properties (Dinand et al. 1996)
38. Physico-chemical and microbiological aspects in composting of grape pulps (Faure & Deschamps 1990)
39. Production of Fungal β-amylase and Amyloglucosidase on Some Nigerian Agricultural Residues (Adeniran et al. 2010)
40. Production of pectin lyase by solid state fermentation of sugarcane bagasse using Aspergillus niger (Ramanujam et al. 2008)
41. Protein, Mineral Content and Amino Acid Profile of Sorghum Flour as Influenced by Soybean Protein Concentrate Supplementation (Awadalkareem et al. 2008)
42. Quality and chemical composition of cassava wastes ensiled with albizia saman pods (Babayerni et al. 2010)
43. Relative fibrolytic activities of anaerobic rumen fungi on untreated and sodium hydroxide treated barley straw in in vitro culture (Rezaeian et al. 2005)
44. Removal of methylene blue from aqueous solution using cotton stalk, cotton waste and cotton dust (Ertas et al. 2010)
45. Rice straw degradation and biomass synthesis by rumen micro-organisms in continuous culture in response to ammonia treatment and legume extract supplementation (Broudiscou et al. 2003)
46. Saccharification of cellulosic waste materials
47. Sorghum and Millet in African Nutrition

48.	Structural Carbohydrate Differences and Potential Source of Dietary Fiber of Onion (Allium cepa L.) Tissues (Jamie et al. 2002)
49.	Studies on the composition of sunflower seed heads (Edrees et al. 2007)
50.	Subcritical water extraction of flavonol quercetin from onion skin (Ko et al. 2011)
51.	The effects of banana peel preparations on the properties of banana peel dietary fibre concentrate (Wachirasiri et al. 2009)
52.	Total Dietary Fibre of Some Wastes as Determined by the Difference Method (Gaonkar & Kulkarni 1989)
53.	Wheat straw as a Paper fiber source

Through this thorough search and reading we were able to sort out important data about chemical content and made an excel-file making it possible to compare each raw material against each other. The raw materials are selected by the given raw materials' chemical content. The preferred content consists of, most important, high content of cellulose, and preferred amounts of chemical compounds like hemicellulose, lignin, pectin and protein, see Appendix A, *Chemical composition of raw materials.xlxs.* These variables were chosen by experts at Borregaard based on how the chemical contents will affect the output and it's suitability to the process.

To assure validity of the data, we collected information on each and one of the raw materials from 53 reports. Some raw materials have not been researched a lot earlier, and therefore it can't be found lots of scientific reports on these, e.g. for yams. Data on chemical content of each raw material was then calculated into an average of all findings related to a raw material, like for example pulp and stalks, to prevent big deviation in the numbers.

Table 2: Example on average calculation on data from several reports (Abstract from Chemical composition of raw materials, Rostad & Larsen, 2011)

Raw materials (and variety)	Cellulose %	Hemicellulose %	Lignin %
Grapes:	27,58	17,34	39,89
Pulp	*22,50*	*9,20*	*39,40*
Stalks (Goering-VS. method)	*37,88*	*14,93*	*32,98*
Stalks (Sluiter method)	*25,30*	*13,95*	*47,29*
Stalks (Bellucci method)	*24,65*	-	-

It's important in this context to mention that Borregaard didn't need 100% accurate numbers at this early stage and therefore wanted us to do approximate calculations. The project of making "Special" is at the moment at a "mapping stage" and therefore don't need the most accurate and complex information yet. If they had to have 100% correct numbers, the only way would be to test each raw material in a lab or pilot plant.

Much of January was spent on searching for fruit producers on Borregaard's request. They mentioned that citrus, tomatoes and apples generated a lot of waste and probably are well suited for the purpose. We contacted numbers of industries that process fruits globally trying to find numbers on waste volumes and how it was treated. It was hard to get response from the firms, because this information is highly confidential for some industries. As with all studies, it's a matter of trying and failing before reaching the goals. Later on this proved to be a bit waste of time, after discovering that other fruit and vegetable productions could be more interesting than from citrus', tomatoes and apples. A lot of time was used, but it gave us some important insight as well.

Borregaard was also a bit unclear on which chemical compounds they needed information on in the start. If this was because of uncertainty or just some lack communication at Borregaard we don't know. Anyway, this meant that we had to go back to most of the reports several times reading and looking for more chemical contents instead of finding these when reading it the first time. We also got more technical insight on the way, so the development of our knowledge made us more deliberate of what chemical factors that we needed.

When we had gotten some basic knowledge and had started collecting data on chemical content we also started the research for Q2: "*Which raw material sources are available, and where are they located?"*. Having the basic knowledge made us capable of knowing approximately where it could be big sources of the raw materials. This was a search task we had to do before we could decide which raw materials to find chemical content of and do comparisons on.

Talking to producer associations and big companies worldwide gave us an overview of the available volume and also got us closer to the necessary datasets. The biggest associations and companies worth a mentioning here are: International Federation of Fruit juice producers (IFU), European Fruit Juice Association (AIJN), The European Food Information Council (EUFIC), The European Fresh Produce Association (FRESHFEL), International Pectin Producers Association (IPPA), Food and Agriculture Organization of the United Nations (FAO), CitrusBR, Fiberstar and Herbstreith & Fox.

The reason for talking to these exact organizations and companies was because we wanted to map the volumes of waste from fruit and vegetable production globally. This way we could point out where to possibly get raw materials to the production of "Special". As mentioned earlier, it was hard to get the wanted data, because of confidentiality and merely because of lacking information of waste documentation from the producers and associations. Appendix B shows the mailing process we have done during the research to get required data related to waste sources and other information. All communication with Borregaard is omitted.

After much back and forth with associations and fruit/vegetable producers around the world we finally found what we were looking for. FAO, (The Food and Agricultural Organization of the United Nations 2011), have big statistic databases and through several searches in these, we could create a dataset with necessary information. The data collected from the FAO statistics was put together for a comparison on which countries having what kind of waste and how big of a volume (FAOSTAT 2011). Together with Borregaard we decided to limit the raw material list of chemical composition to the 30 biggest sources of waste globally.

All these collected data made it possible to start analyzing and getting results and conclusions on the research questions.

3.3 Methods for analyzing data

The objective of analyzing the data was first to compare all possible raw materials' chemical content and find the best suited materials for the production. To do this we had to find which chemical contents are the most important ones for the production and appraise these against each other. This way we can determine how well suited the raw materials will be for the process. Borregaard's research department has given all the chemical content that will affect the raw material's suitability for the production process. Our object was therefore to collect data, and then compare the raw materials based on Borregaard's statements.

The second objective was to find how much waste that's available and where in the world it's available. How much it will approximately cost to buy these volumes is also of interest. On this objective we compared quantitative data on volumes of different raw material sources to find which countries that have big enough volumes of the raw materials. This could lead us closer to where in the world to place the production. In addition to this Borregaard wanted us to calculate prices on these volumes given different kind of price drivers. We have calculated it in the analysis, but because of time limits we had to take it for granted that the prices are the same all over the world in this study. This is off course not the truth, but finding and

comparing prices in all countries is a whole study itself. Anyhow, this will be an important task in further research in order to be able to find the perfect production location.
Third, and last, the objective is to combine the two first objectives to find the best location based mainly on where in the world the best suited raw materials are in large enough volume for production. This will be analyzed with a theoretical perspective.

3.4 Limitations

The main goals of this study is to find the best suited raw material for production of "Special" and where to place the production of the product. There are a lot of factors affecting both of these goals and given the time and resources, some limitations had to be done. It's of importance to discuss weaknesses and shortcomings of a study. Many shortcomings in this thesis are because of lack of time.

Our method is using mostly qualitative secondary data. Given more time, it could have been more preferable to also use a more causal design on the first part of the method with testing and experimenting in a lab. A thorough lab testing of each raw material would give us perfect results and exact data on chemical content.

With more time it would also be possible to look at more location factors. Because this is in the very beginning of the project there are a lot of factors lacking when it comes to the decision of location. This is because these factors are of no interest at the very moment, but will be more important when the project gets further. The choice of location can make the difference between failure and success. When choosing a location for production a huge amount of factors has to be taken into consideration if wanting to lower the risk of failure (Arauzo-Carod & Manjón-Antolín 2007). Such factors could have been salaries, culture, tax levels, corruption risk, and logistics and so on. If taken more factors into consideration, the validity of the results of this thesis on location decision would also have been much stronger. Because most of the experts at R&D at Borregaard also have other tasks not concerning this project, some of our inquiries have gone a bit slow. We have had to wait for answers and have also been "fumbling a bit in the dark" trying to do research on things we don't have any knowledge of. With more resources and experts to do this, it could have taken much less time. Another limitation is FAO's datasets. They are just documenting waste including 2007 and will possibly differ from today's reality.

3.5 Validity

Data will always just be a representation of the reality, not the reality itself.

Validity in qualitative research concerns the extent of how the researcher's procedures and findings reflect the objective of the study and represents the reality in a good manner.

(Johannessen et al. 2006)

Because of this it's important to ask the question of how good the data represent the reality. The research question and the methods used in this study are by our perceptions reflecting the objective of the study and representing the reality. With the study's research questions we are able to reach the goals of the study through use of appropriate methods getting results that represents the reality in a good way.

The study will give results that could be taken into use in other context, and therefore also have a certain external validity. The data could for example be used in projects where comparisons of fruit waste's chemical content are needed for production of other products. The data can also be used for finding new uses of this kind of waste, an important task for achieving an eco-friendly future. At the moment Borregaard want to keep the results for themselves, but will be using them in EU-projects they are intended to join in the future.

3.6 Reliability

In all research and studies the data's reliability are very important. Reliability is about the accuracy of the data, how it's collected and used, and how it's processed.

The reliability in this study much relies on the reliability of the data sources. Most of the data are secondary data and criticism of the sources is an important factor when collecting such data. Only what we consider as reliable sources have been used in the data collection. The sources used are only well known scientific sources and recognized associations and publishers, like Elsevier and Bioresource Technology. All our collected data is also checked with the experts at Borregaard to assure reliable data. Several data sources have also been used to compare data and lower the risk of incorrectness in the data sets. For instance we have compared the cellulose-, hemicellulose- and lignin content of lemon from two different scientific researches.

However, because of some limitations there is some weakness in the reliability that needs to be mentioned. Given the time and the limitations given by Borregaard, we have used mostly secondary data that are intended for other uses than this. The scientific researches used for this project is using different methods for analyzing the chemical contents, which might give differences in the results. The data can be used for this study giving good and reliable enough results for Borregaard, but it can't be ruled out that some data might not be 100% correct. The only way to get 100% correct measures of the chemical content of the waste is to do tests in a lab, which wasn't desirable for Borregaard at the moment. A few of the components in the data set on chemical composition are therefore either missing or calculated from other contents. This gives results more than good enough for this study and use at this moment in the project, and is therefore not seen upon as a big issue.

In addition to this, the waste volumes from FAO bring some issues. The data doesn't say exactly where in each country the waste volumes are located and how it's treated. Furthermore it doesn't say anything about the wastes' condition, just its source. This study will therefore focus on waste amount by countries and take it for granted that the waste can be used for Borregaard's purpose.

3.7 Choice of theory

There are several theories which are relevant to use for this thesis. The Q1: "*Which raw materials are best suited for the production?*" is especially related to chemical theory. It's not the intention for us to present chemical theory, but it's necessary to have some chemical insight to do the technical analysis. Borregaard is therefore helping us with the chemical section, so we are able evolve and understand this part.

The main theoretical part of this thesis will therefore focus on location theory, which is relevant to our innovation and entrepreneur education. The location theory is particularly related to the Q2 and Q3: "*Which raw material sources are available, and where are they located?" and "Where will it be the most preferable to place the production?"*.

4. Findings

The following section will present the data found through the research followed by a chapter with discussion of the data. The findings will follow the same structure as the research design presenting the findings from the research for Q1 first and findings for Q2 and Q3 secondly. These data will be the background for the discussion towards the research questions and lead to a conclusion on the key research question in chapter 6.

The tables presented in this thesis will because of size only be segments of whole spread sheets, to make an understanding of the data and show examples. See the attached CD for complete spread sheets in excel.

4.1 Findings on chemical composition

The research was started in the beginning of January 2011 searching first for citrus producers around the world because this, together with tomato and apple, would be the most profitable industry to look into. This was given by Borregaards' early hypothesis that wastes from these fruits and vegetables might be the best suited raw materials for the production.

We were also asked by Borregaard to find dietary fiber and cellulose content in each raw material because of its significance to the production process' output. Collecting and reading scientific reports on chemical compositions gave these results for the given raw materials, ranked by the cellulose content:

Table 3: Ranking of the first explored raw materials (Abstract from Chemical composition of raw materials, Rostad & Larsen, 2011)

Raw materials	Cellulose %	Total Dietary fiber %
Apple:	43,60	76,23
Grapefruit:	26,57	53,40
Lemon:	24,00	64,20
Tomato:	19,70	78,73
Orange:	18,80	64,30

Apple is at the top of the rankings on these 5 raw materials. The waste from apples has more than twice the amount of cellulose than waste from orange, and also significantly more cellulose than the other sources on the list. This means that apple would potentially give a good output if used as raw material in the production.

Searches in several databases as the USDA National Nutrient Database for Standard Reference (USDA National Nutrient Database 2011) and the fact that apples had so much higher cellulose content, gave us a suspicion that other raw materials than citrus would be preferable for the production. Finding data sources of waste from all fruit and vegetables in different countries for Q2 and Q3 also gave an insight in which other raw materials we had to focus on.

Throughout the research and data collection process Borregaard came with feedback to our findings, and some other search criteria were set. In addition to cellulose and dietary fiber also hemicellulose and lignin would be interesting for Borregaard. The amount of cellulose will directly affect the output ratio while the amount of hemicellulose and lignin is important because this affects the actual process. Later on protein and pectin were also added to the list because of its role as price driver in alternative products made of the same raw materials that Borregaard wants to use.

After getting onto “the right track” the data showed a different reality than the first hypothesis of citrus, tomato and apple being the most important raw materials to look into. Reading through more than 220 reports on chemical composition gave us a better understanding. The reports clearly show that citrus fruits might not be the most suitable and profitable raw material to use. We sorted out possible raw materials by research on chemical content and which ones being available in big volumes around the world. This gave a first sorting on 30 possible raw materials of waste from fruits and vegetables. The cellulose content of the raw materials ranges from a high at almost 72 % to a low of just
1,63 %.

The results are presented in this list, showing the percentage of chemical contents of all the raw materials:

Table 4: Chemical compositions of the raw materials (Rostad & Larsen 2011, full spread sheet on CD, Appendix A)

Raw materials	Cellulose %	Hemicellulose %	Lignin %	Total Dietary fiber %	Insoluble Fiber %	Soluble Fiber %	Protein %	Pectin %
Apple	43,60	24,40	20,40	76,23	67,33	8,89	3,48	11,70
Banana	25,60	10,10	12,30	50,25			8,60	17,35
Barley	52,70	26,50					3,62	
Coconut	19,80			84,62			2,00	
Cassava	14,00	27,00					3,50	
Cotton seed	40,90	12,80	15,37				35,80	
Grapes	27,58	17,34	39,89				9,75	3,62
Grapefruit	26,57	5,59	11,56	53,40	46,90	5,50	8,46	8,53
Lemon	24,00	8,15	5,61	64,20	55,64	12,92	7,61	17,77
Maize/Corn	71,77	15,78	0,27	13,55	12,35	1,96	9,45	3,50
Mustard seed	48,60	12,30	14,50				4,50	
Oats	23,30	17,67	9,93				8,67	
Onion	8,85		24,79	34,69	29,50	5,49	3,98	
Orange	28,55	8,26	7,41	64,30	54,00	10,28	8,80	12,87
Pineapple	10,73	6,07	10,51				2,45	6,30
Plantains	6,90	1,30	15,50				11,82	17,65
Potato	9,60	7,90					2,25	9,60
Rapeseed	35,59	24,11	30,10				3,03	
Rice	34,25	25,70	10,00				3,69	3,10
Rye	30,90	21,50	25,30				3,30	
Seaweed	3,90			42,57	13,33	29,24	14,89	
Sorghum	64,95		7,75				12,20	
Soybean	44,00						16,24	
Sugar Beet	22,00	32,00	2,00				7,00	27,00
Sugar Cane	41,00	24,00	18,00				2,00	0,10
Sunflower seed	18,93	13,72	8,92				13,12	11,85
Sweet Potato	1,63			11,20	5,44	5,74	4,63	2,96
Tomato	19,70	36,50	13,80	78,73	71,52	7,21	11,01	9,70
Yams	2,08			6,93			1,80	2,47
Wheat	35,30	28,50	19,50				2,33	5,00

The top three raw materials ranked by cellulose content are all different sorts of grain. Maize/corn, sorghum and barley has a cellulose content of 71,77 %, 64,95 % and 52,7 %. Citrus fruits in general have only a medium amount of cellulose content between 18 % and 27 %. Sorts of potato like yams and sweet potato have an even lower score on the cellulose content leaving them at the bottom part of the rankings together with seaweed. Seaweed was examined on Borregaard's request because of large volumes in Asia. Little scientific reports on this raw material have been written, and lab tests should be done to find all the chemical compounds. Anyway, seaweed ranks very close to the bottom on cellulose content and would probably not give a high output rate. The *table 5* shows the raw materials' content of cellulose, hemicellulose and lignin. The table is an extraction from *table 4* and ranks the raw materials by cellulose content.

Table 5: The raw materials ranked by cellulose content (Rostad & Larsen)

Raw materials	Cellulose %	Hemicellulose %	Lignin %
1. Maize/Corn	71,77	15,78	0,27
2. Sorghum	64,95	-	7,75
3. Barley	52,70	26,50	-
4. Mustard seed	48,60	12,30	14,50
5. Soybean	44,00	-	-
6. Apple	43,60	24,40	20,40
7. Sugar Cane	41,00	24,00	18,00
8. Cotton seed	40,90	-	15,37
9. Rapeseed	35,59	24,11	30,10
10. Wheat	35,30	28,50	19,50
11. Rice	34,25	25,70	10,00
12. Rye	30,90	21,50	25,30
13. Grapes	27,58	17,34	39,89
14. Banana	25,60	10,10	12,30
15. Grapefruit	26,57	5,59	11,56
16. Lemon	24,00	8,15	5,61
17. Oats	23,30	17,67	9,93
18. Sugar Beet	22,00	32,00	2,00
19. Coconut	19,80	-	-
20. Tomato	19,70	36,50	13,80
21. Sunflower seed	18,93	8,15	8,92
22. Orange	18,80	8,24	5,71
23. Cassava	14,00	27,00	0,00
24. Pineapple	10,73	6,07	10,51
25. Potato	9,60	7,90	-
26. Onion	8,85	-	24,79
27. Plantains	6,90	1,30	15,50
28. Seaweed	3,90	-	-
29. Yams	2,08	-	-
30. Sweet Potato	1,63	-	-

The amount of the two chemical compounds hemicellulose and lignin are also important to map in order to see the suitability for the process. *"More hemicellulose, easier to process. Less lignin to delignificate, more suitable."* This is given if the raw material doesn't need to be pre-processed before Borregaard takes it into the actual production process. If the application needs a super-clean product, then all raw materials will need to be purified before the process. Then it would be best having a low amount of both hemicellulose and lignin (Øvrebø 2011a).

Oranges has a low content of both hemicellulose and lignin on respectively 8,24 % and 5,71 %, which is almost equal to lemon. Maize with the highest cellulose content has a medium amount of hemicellulose on 15,75 %, and an extremely low content of lignin at just 0,27 %. Grapes, on the other hand, have a medium amount of both cellulose and hemicellulose, but a rather high volume of lignin, making it probably more difficult to process.

In the end of the research period we were asked by Borregaard's business manager Per-Ivar Heier to take a last quick look into pectin producers as well to get an overview of possible big competitors or collaboration partners. The pectin production industry seems to consist of few, but big companies, and according to International Pectin Producers' Association (IPPA 2011) these are the 6 largest pectin producers (in order of magnitude):

1. CP Kelco (Formerly best known as "Copenhagen Pectin" producing in Denmark, Germany and Brazil)
2. Danisco (Producing in Mexico and Czech Republic)
3. Cargill (Formerly best known as "Unipectine" producing in France and Germany)
4. Herbstreith & Fox (Producing in Germany)
5. Andre Pectin (Producing in China)
6. Obipektin (producing in Switzerland)

(Højegaard Christensen 2011)

Pectin is typically extracted from citrus peel, apple pomace or sugar beet residues. Residues being all waste material from juice and sugar production. After the pectin is extracted, the material left over is mainly cellulose and hemicellulose. This final waste is typically utilized as cattle feed. This means that buying this leftover will give Borregaard a super clean input for the production process at a possible low price given that this normally would be sold or given away as cattle feed. According to executive secretary at IPPA, Steen Højegaard Christensen, looking at the worldwide pectin production, dry matter of the waste material will amount to between 100 000 and 200 000 metric ton per year (Højegaard Christensen 2011). Some of the pectin producers are also using the waste from the production to make byproducts of the remaining contents such as cellulose for fiber products, like fat replacement in food. These producers will naturally be competitors, while the pectin producers who don't use their waste for this particular use will be possible suppliers for Borregaard.

4.2 Findings on location

Data from the FAO Statistic Database (FAOSTAT 2011) gave us an opportunity to make excel spread sheets showing which countries that have the most waste from each of the raw materials. A first sorting of what kind of waste volumes that occur in each continent was made to give an overview. We have eliminated Oceania from our spread sheets because of very low amounts of waste in the Oceanic countries. The data show that there are some variations from continent to continent of which raw materials that have big volumes of waste. Anyhow, some of the raw materials can be found in big volumes in all continents. Waste from maize for instance is among top 4 in volume in all continents. A first glance at the total volumes in the world shows that the 5 biggest volumes of waste in 2007 came from sugar cane, rice (paddy eq.), maize, rice (milled eg.) and potatoes.

Table 6: Top ten waste sources globally (Rostad & Larsen 2011, full spread sheet on CD, Appendix C)

World (Total)			
Item	Element	2006	2007
Sugar Cane	Waste (tonnes)	29 522 150	59 353 030
Rice (Paddy Equivalent)	Waste (tonnes)	36 678 468	37 656 945
Maize	Waste (tonnes)	26 942 111	28 832 240
Rice (Milled Equivalent)	Waste (tonnes)	24 464 538	25 117 182
Potatoes	Waste (tonnes)	22 037 976	23 004 592
Cassava	Waste (tonnes)	21 347 804	20 899 509
Wheat	Waste (tonnes)	19 955 561	19 773 944
Bananas	Waste (tonnes)	11 192 732	11 848 435
Tomatoes	Waste (tonnes)	10 640 367	11 068 585
Oranges, Mandarines	Waste (tonnes)	6 774 527	6 829 004

Sugar cane is by far the biggest source of waste when total volumes in the world are measured. In 2007 there was a 59 353 030 tons of waste from sugar cane production. For comparison orange production had a waste amount of 6 829 004 ton in 2007, leaving oranges on a 10th place of biggest waste volumes from fruit and vegetables in the world.

The datasets on waste volumes was divided into top 3 waste sources in each continent with top 3 countries per each waste source. This was done to get a step closer to find an appropriate location for the production. Data on each continent and countries shows that some countries stand out. Mostly these are large countries with big natural resources. In Europe both Germany and Poland stand out having huge amounts of waste from several of the raw materials.

Table 7: Top three waste sources and countries in Europe (Rostad & Larsen 2011, full spread sheet on CD, Appendix C)

Europe				
Country	Item	Element	2006	2007
Poland	Potatoes	Waste (tonnes)	800 000	1 000 000
Germany	Potatoes	Waste (tonnes)	820 205	920 395
France	Potatoes	Waste (tonnes)	707 000	710 000
Turkey	Wheat	Waste (tonnes)	2 150 000	2 150 000
Germany	Wheat	Waste (tonnes)	548 000	500 000
Poland	Wheat	Waste (tonnes)	347 663	447 719
Ukraine	Maize	Waste (tonnes)	360 000	416 000
Serbia	Maize	Waste (tonnes)	300 916	195 289
Greece	Maize	Waste (tonnes)	170 466	182 877

In America Brazil is definitively the biggest source of waste from fruit and vegetable production. No other country has nearly as much waste as Brazil in the American continent. For instance Brazil produced more than 45,7 million tons of waste from sugar cane production alone. Mexico produced the second most waste from sugar cane, but the amount was equal to just 2,27 % of the Brazilian amount.

Worth a mentioning is that Brazil reuses a lot of their waste. According to the Ethanol Producer Magazine, Brazil is the second largest global producer of ethanol, and a lot of the waste from especially sugar canes goes to this production (Geiver & Jessen 2010).

Table 8: Top three waste sources and countries in America (Rostad & Larsen 2011, full spread sheet on CD, Appendix C)

America				
Country	Item	Element	2006	2007
Brazil	Sugar Cane	Waste (tonnes)	17 770 660	45 754 340
Mexico	Sugar Cane	Waste (tonnes)	1 013 516	1 041 787
Ecuador	Sugar Cane	Waste (tonnes)	349 781	418 000
Brazil	Maize	Waste (tonnes)	4 361 806	5 320 774
Mexico	Maize	Waste (tonnes)	3 835 696	3 718 126
Canada	Maize	Waste (tonnes)	326 663	426 835
Brazil	Cassava	Waste (tonnes)	2 663 901	2 654 120
Paraguay	Cassava	Waste (tonnes)	480 000	480 000
Peru	Cassava	Waste (tonnes)	354 376	359 022

In Asia China and India are naturally the two biggest waste sources and are present at the list of the top three countries of all the top three raw materials' waste volumes. In total, the two types of rice are by far the raw materials with the biggest volumes of waste in Asia.

Table 9: Top three waste sources and countries in Asia (Rostad & Larsen 2011, full spread sheet on CD, Appendix C)

Asia				
Country	Item	Element	2006	2007
China	Rice (Paddy E.)	Waste (tonnes)	8 716 499	8 772 581
Indonesia	Rice (Paddy E.)	Waste (tonnes)	4 333 137	4 616 955
India	Rice (Paddy E.)	Waste (tonnes)	4 174 110	4 337 100
China	Rice (Milled E.)	Waste (tonnes)	5 813 905	5 851 312
Indonesia	Rice (Milled E.)	Waste (tonnes)	2 890 202	3 079 509
India	Rice (Milled E.)	Waste (tonnes)	2 784 131	2 892 846
India	Potatoes	Waste (tonnes)	4 959 690	4 861 952
China	Potatoes	Waste (tonnes)	2 786 013	3 248 877
Russia Federation	Potatoes	Waste (tonnes)	1 659 000	1 825 700

In Africa the data shows that Nigeria has huge amounts of waste from many of the raw materials on our lists. Even though cassava and yams don't have the biggest amount of cellulose there's much waste from these productions and many of the more cellulose intensive raw materials is not far behind in waste volumes either.

Table 10: Top three waste sources and countries in Africa (Rostad & Larsen 2011, full spread sheet on CD, Appendix C)

Africa				
Country	Item	Element	2006	2007
Nigeria	Cassava	Waste (tonnes)	5 245 115	4 979 995
Ghana	Cassava	Waste (tonnes)	2 892 856	2 896 412
Angola	Cassava	Waste (tonnes)	1 100 000	1 120 000
Nigeria	Yams	Waste (tonnes)	3 672 000	3 113 600
Côte d'Ivoire	Yams	Waste (tonnes)	556 900	584 221
Ghana	Yams	Waste (tonnes)	550 000	550 000
Egypt	Maize	Waste (tonnes)	887 420	932 612
Nigeria	Maize	Waste (tonnes)	779 273	750 987
Tanzania	Maize	Waste (tonnes)	423 900	424 499

A ranking of the countries in each continent by the biggest volumes of all raw materials clearly show which countries that have many big raw material sources. The following list shows the top 15 sources of waste in the European continent, it's an abstract from Appendix D, *All waste per country by continents*. In Europe there's not as distinct differences in waste volumes from country to country as in the other continents. Therefore it's more difficult to see which country having the most and biggest waste volumes in total and differentiate them from one another. Anyway, Germany is high up on several of the raw materials, not only on the mentioned top 3, but also on raw materials such as barley and tomatoes. Germany has also a few really big juice and pectin producers in the country who produce a fair amount of waste.

Table 11: Top fifteen sources of waste in Europe (Rostad & Larsen 2011, full spread sheet on CD, Appendix D)

Europa			
Countries	Item	Element	2007
Poland	Potatoes	Waste (tonnes)	1000000
Germany	Potatoes	Waste (tonnes)	920395
France	Potatoes	Waste (tonnes)	710000
Belgium	Potatoes	Waste (tonnes)	510000
Germany	Wheat	Waste (tonnes)	500000
Poland	Wheat	Waste (tonnes)	447719
Ukraine	Maize	Waste (tonnes)	416000
Spain	Oranges, Mandarines	Waste (tonnes)	357937
Ukraine	Wheat	Waste (tonnes)	355028
France	Wheat	Waste (tonnes)	300000
United Kingdom	Wheat	Waste (tonnes)	280000
Germany	Barley	Waste (tonnes)	271000
Ukraine	Potatoes	Waste (tonnes)	248000

Denmark	Potatoes	Waste (tonnes)	244000
Italy	Apples	Waste (tonnes)	227351

Ranking the American volumes also shows clearer in this ranking that there's one country standing out. Brazil clearly has a lot of big sources covering several of the listed raw materials:

Table 12: Top fifteen sources of waste in America (Rostad & Larsen 2011, full spread sheet on CD, Appendix D)

America			
Countries	Item	Element	2007
Brazil	Sugar Cane	Waste (tonnes)	45754340
Brazil	Maize	Waste (tonnes)	5320774
Mexico	Maize	Waste (tonnes)	3718126
Brazil	Cassava	Waste (tonnes)	2654120
Brazil	Oranges, Mandarines	Waste (tonnes)	2049810
Brazil	Rice (Paddy Equivalent)	Waste (tonnes)	1320836
United States of America	Potatoes	Waste (tonnes)	1319770
Brazil	Bananas	Waste (tonnes)	1064754
Mexico	Sugar Cane	Waste (tonnes)	1041787
Brazil	Rice (Milled Equivalent)	Waste (tonnes)	880998
United States of America	Tomatoes	Waste (tonnes)	762799
Peru	Potatoes	Waste (tonnes)	705774
Mexico	Wheat	Waste (tonnes)	643318
Argentina	Wheat	Waste (tonnes)	581638
Peru	Plantains	Waste (tonnes)	574928

Ranking the Asian volumes shows even clearer than the top 3 rankings that China and India has the most waste from many of the raw materials.

Table 13: Top fifteen sources of waste in Asia (Rostad & Larsen 2011, full spread sheet on CD, Appendix D)

Asia			
Countries	Item	Element	2007
China	Rice (Paddy Equivalent)	Waste (tonnes)	8772581
China	Maize	Waste (tonnes)	6330576
China	Rice (Milled Equivalent)	Waste (tonnes)	5851312
India	Sugar Cane	Waste (tonnes)	5332796
India	Potatoes	Waste (tonnes)	4861952
India	Bananas	Waste (tonnes)	4640960
Indonesia	Rice (Paddy Equivalent)	Waste (tonnes)	4616955
India	Rice (Paddy Equivalent)	Waste (tonnes)	4337100
China	Sweet Potatoes	Waste (tonnes)	3786680

Viet Nam	Rice (Paddy Equivalent)	Waste (tonnes)	3432686
China	Potatoes	Waste (tonnes)	3248877
Myanmar	Rice (Paddy Equivalent)	Waste (tonnes)	3145000
Indonesia	Rice (Milled Equivalent)	Waste (tonnes)	3079509
Bangladesh	Rice (Paddy Equivalent)	Waste (tonnes)	3017815
India	Rice (Milled Equivalent)	Waste (tonnes)	2892846

The African ranking shows that Nigeria has without a doubt many big potential sources of raw materials. The West African country is at the top 15 lists with waste from cassava, yams, sugar cane, maize and sweet potato.

Table 14: Top fifteen sources of waste in Africa (Rostad & Larsen 2011, full spread sheet on CD, Appendix D)

Africa			
Countries	Item	Element	2007
Nigeria	Cassava	Waste (tonnes)	4979995
Nigeria	Yams	Waste (tonnes)	3113600
Ghana	Cassava	Waste (tonnes)	2896412
Angola	Cassava	Waste (tonnes)	1120000
Nigeria	Sorghum	Waste (tonnes)	1034631
South Africa	Sugar Cane	Waste (tonnes)	986200
Egypt	Maize	Waste (tonnes)	932612
Egypt	Wheat	Waste (tonnes)	887863
United Republic of Tanzania	Bananas	Waste (tonnes)	875000
Egypt	Tomatoes	Waste (tonnes)	863902
Nigeria	Sugar Cane	Waste (tonnes)	753810
Nigeria	Maize	Waste (tonnes)	750987
Nigeria	Sweet Potatoes	Waste (tonnes)	729600
Uganda	Plantains	Waste (tonnes)	700000
Côte d'Ivoire	Yams	Waste (tonnes)	584221

One question is important to find an answer to; how much will these volumes cost to buy use in the production?

4.3 Value calculations with different price drivers

Combining the data on chemical content with the data on volumes of waste we can calculate how much it would cost Borregaard to buy these amounts of waste to use in the production. To calculate the prices for the raw materials these following calculations were used: Cellulose will most likely be the price driver when the cellulose content is high and the raw material could be used for ethanol production. One ton of cellulose gives 600 liters of spirits.

To find the value of the total cellulose content of the waste, the volume is multiplied by 600. This is then multiplied with the ethanol price per liter, which is 4 Norwegian kroner. To get the numbers in dollars, the Norwegian kroner is divided with 5,67, which was the exchange rate per 16th of March 2011 at 12:55pm (Oslo Børs 2011). In other words the price per ton of pure cellulose is 600 x 4NOK = 2400NOK. In dollar this is equal to $ 423,28 per ton.

Applied to the volumes of sugar cane in Brazil the calculation is this:

Waste volume in Brazil = 45 754 340
Cellulose content of sugar cane 41 %
45 754 340 x 0,41 = 18 759 279 (total cellulose content)
(18 759 279 x 600) x (4nok/$5,67) = <u>$7 940 435 556</u>

Pectin will be the price driver if the pectin content is high and therefore often used for several different pectin products such as starch additive in food. The value of the raw material if pectin is the price driver is calculated by multiplying the amount of pectin in the given raw material with the pectin price per ton which is $13585 (IMR International 2010).

Contact with juice producers and organizations such as Citrus BR, Bramhults and Verband der deutschen Fruchtsaft-Industrie and several Norwegian fruit processors, clearly show that the waste very often is used as cattle feed or sold for animal feed production, see Appendix E. This is if the raw material has a high content of protein, and the protein therefore can be a price driver. The value of the raw material is then calculated the same way as pectin, but with the price of protein per ton. Together with Knut Røflo at *Felleskjøpet's Fôrutvikling*, we estimated the protein price to $580 per. ton based on numbers from 2010, see Appendix F.

With these calculations the price for buying the total volumes of the top 5 raw materials in the world are shown in the table. The calculations have been done to show an example of the difference in price between the raw materials and with different price drivers.

Table 15: Value calculations of top five global waste sources (Rostad & Larsen 2011, full spread sheet on CD, Appendix C)

Value			
			Alternative waste
Item	Cellulose (ethanol value)	Pectin (pectine value)	Animal feed (protein value)
Sugar Cane	10 300 420 021	806 310 913	688 495 148
Rice (Paddy Eq.)	5 459 260 810	15 858 657 533	805 933 937
Maize	8 758 898 899	13 709 009 314	1 580 295 074
Rice (Milled Eq.)	3 641 326 914	10 577 724 442	537 557 929
Potatoes	934 789 770	30 001 668 703	300 209 926

In addition to these 3 price drivers, burning value has to be mentioned as well. Some of the raw materials are burned for heat and energy production. The value of this will have big differences from country to country, but all the above mentioned price drivers will always have a higher price than the burning value. The burning value will also be affected of the moisture of the material. With moisture content over 50% there will be no value of burning. Use of the raw material for other purposes will therefore always be preferred over the value of burning. If there are no possibilities for making a value of the raw materials other than through burning at a given location, the raw material most likely will have a lower price compared to others (Øvrebø 2011b).

Worth a mentioning is that the price will not only be decided from *one* of the price drivers. A combination of one or more of the price drivers, depending on the amount of cellulose, pectin and protein in the given raw material will affect the price in total. In some occasions the raw material can be used in one production process first and then used for other production processes afterwards. For instance, it can be used for production of pectin first, and for production of "Special" afterwards, because the pectin process doesn't utilize the cellulose.

5. Discussion

This chapter will discuss the findings in chapter 5, perform a deeper analyze, and emphasize determinant results from the research regarding the key research questions and its specific questions. There will also be presented a theoretical implication of the results related to localization.

5.1 Suitability of the raw materials

The research of this study has given a lot of insight to Q1: "*Which raw materials are best suited for the production?"* By setting up the spreadsheet, *chemical composition of raw materials*, we got a good overview of relevant waste to the purpose. By a using this broad approach we didn't omit any raw materials, but the spreadsheet illustrated quickly that some waste was conspicuous compared to others. The diagram below is illustrating the findings of cellulose content of each raw material. Cellulose is the main content of "Special" and therefore highly important to the input factors and also a determinant sorting parameter.
Top five sources ranked on cellulose content are: waste from maize, sorghum, barley, mustard seed and soy bean.

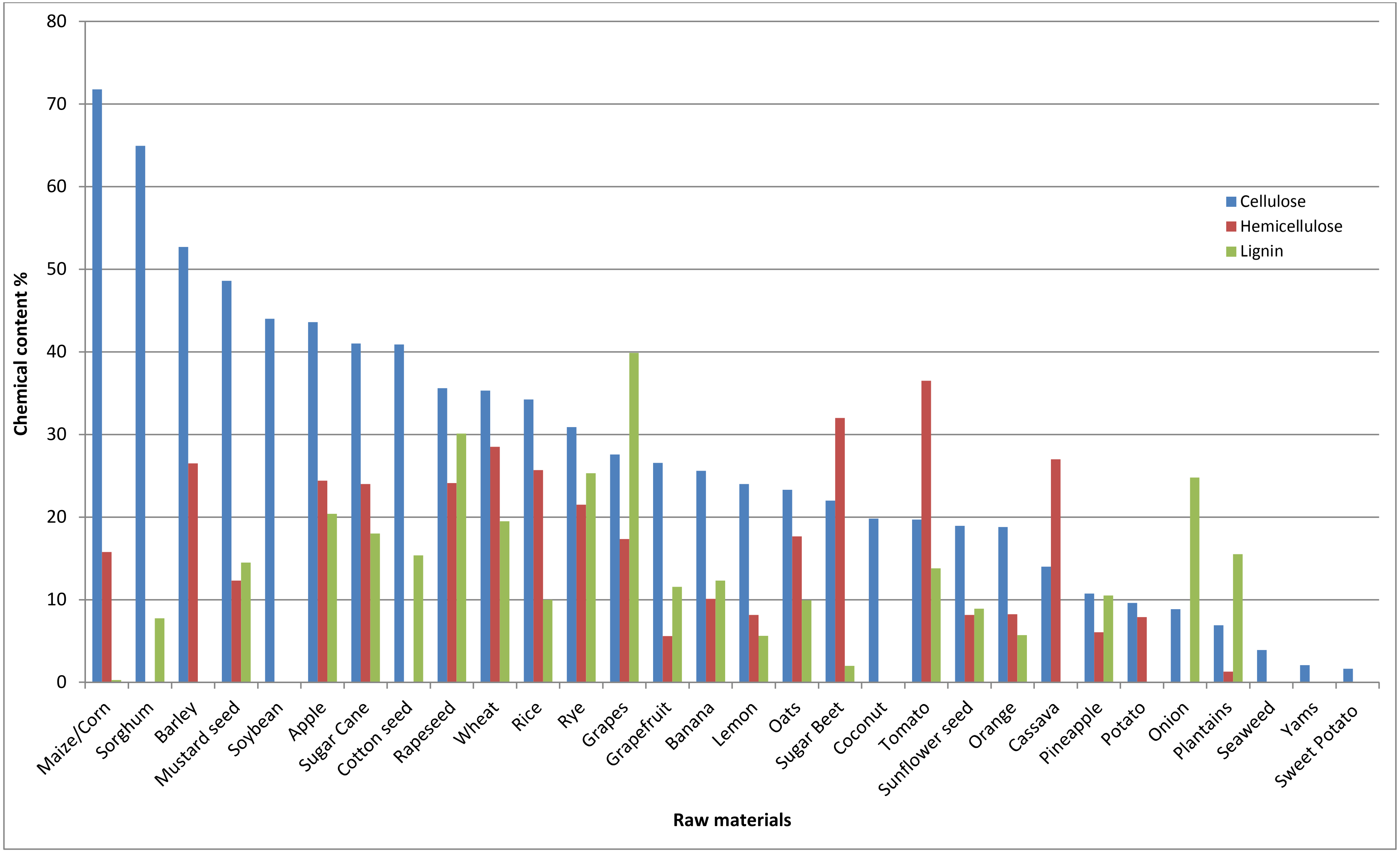


Figure 9: Chemical composition of raw materials

As mentioned in chapter 4, the suitability is also dependent of other factors like hemicellulose and lignin, because of the ability to suit the production. So to decide the best suitable raw materials we also have to take this into consideration. According to Hans Henrik Øvrebø, a scientist at Borregaard the following statements are the guidelines for comparing and choosing the right raw materials: *"More hemicellulose, easier to process. Less lignin to delignificate, more suitable."*

It's important to mention that these statements can depart from the reality. It's just assumptions before lab testing is accomplished, where the combination of moisture content, size, structure, hardness and the chemical composition of each raw material will prove the reality.

It will not be possible to make a complete ranking showing the suitability of the raw materials before they are tested in a lab or pilot plant. Until then it will be impossible to know exact how the three compounds, cellulose, hemicellulose and lignin, should be weighed against each other. Cellulose will always be the most important compound of the three, if higher cellulose level will give a higher output level.

Given the directions from Borregaard on cellulose, hemicellulose and lignin content some raw materials seem more suitable than others. A very important fact is that Borregaard doesn't want to find only one single raw material they want to focus on but probably several. This is because different kind of raw materials will possibly give output with different properties and therefore other uses and several final products. By looking at the diagram on the next page comparisons of all the raw materials are possible. We see that waste from several sources has cellulose content above 40 %, which is very good.

If the application doesn't need a super clean input all raw materials with high levels of cellulose and hemicellulose, and low lignin content will be suitable. Maize has an enormous amount of cellulose and very low lignin content, but just quite low/medium amount of hemicellulose. This might make it difficult to process, but will give a possible huge output. Several of the other raw materials have a lower amount of cellulose, and also quite low lignin, but higher amounts of hemicellulose. Sugar cane, wheat and rice all have more than 30 % cellulose, more than 20 % hemicellulose and lignin content lower than 20%. A cellulose content of approximately 20 % could show to be efficient enough. If so, sugar beet and tomato would also be well suited for the process with its high levels of hemicellulose and small amounts of lignin. Also sorghum and barley should be tested in a lab. If results show that these grains have approximately the same amount of hemicelluloses (missing for sorghum) and lignin (missing for barley) as the other grains, they would also be very well suited for the process.

Table 16: Suitable raw materials if super clean inputs are unnecessary (Rostad & Larsen)

Raw materials	Cellulose %	Hemicellulose %	Lignin %
Maize/Corn	71,77	15,78	0,27
Apple	43,60	24,40	20,40
Sugar Cane	41,00	24,00	18,00
Wheat	35,30	28,50	19,50
Rice	34,25	25,70	10,00
Sugar Beet	22,00	32,00	2,00
Tomato	19,70	36,50	13,80

If a super clean raw material is needed for the application waste from pectin producers will be highly valuable because of its pureness and high content of cellulose. Typical input for pectin producers are as mentioned citrus, apple and sugar beet waste. After pectin is extracted most of needless chemical contents for production of "Special" are eliminated, and necessary contents are still useable. This statement makes these raw materials highly relevant as raw materials. In addition to the raw materials used for pectin maize, mustard seed, banana and sunflower seed have chemical composition well suited for the process with hemicellulose under 16% and lignin under 15%. Sunflower seed and orange might have a bit too low cellulose content, but when pre-processed the cellulose content will increase in relation to the total chemical composition and should be enough.

Table 17: Suitable raw materials if super clean inputs are necessary (Rostad & Larsen)

Raw materials	Cellulose %	Hemicellulose %	Lignin %
Maize/Corn	71,77	15,78	0,27
Mustard seed	48,60	12,30	14,50
Banana	25,60	10,10	12,30
Grapefruit	26,57	5,59	11,56
Lemon	24,00	8,15	5,61
Sunflower seed	18,93	8,15	8,92
Orange	18,80	8,24	5,71

Pectin is furthermore the most expensive price driver. The pectin price per ton is $13585, the protein price per ton $580, and the cellulose price per ton is $423,28. So competing for the raw materials with ethanol and animal feed producers will probably be a cheaper way to get raw materials than to buy raw materials that usually goes to pectin production.

The top 10 raw materials on protein content and pectin content show which ones that is most likely to be used in animal feed or pectin production. Getting the raw materials from the pectin list after the pectin extraction rather than before will be cheaper and cleaner.

Table 18: Top ten raw materials ranked on protein- and pectin content (Rostad & Larsen)

Raw materials	Protein %
Cotton seed	35,80
Soybean:	16,24
Seaweed:	14,89
Sunflower seed:	13,12
Sorghum:	12,20
Plantains	11,82
Tomato:	11,01
Grapes:	9,75
Maize/Corn:	9,45
Oats:	8,67

Raw materials	Pectin %
Sugar Beet:	27,00
Lemon:	17,77
Plantains	17,65
Banana:	17,35
Sunflower seed:	11,85
Apple:	11,70
Orange:	11,70
Tomato:	9,70
Potato:	9,60
Grapefruit:	8,53

The price for the raw materials will probably vary to a certain extent from location to location but the price drivers will be the same.

5.2 Availability of raw materials and their localization

The specific research question Q2: "*Which raw material sources are available, and where are they located?*" is primary answered by data from FAO's Statistic Database. This information is highly relevant to Q3: "*Where will it be the most preferable to place the production?*" because the findings in Q2 point out areas that produce the adequate amount of waste, and therefore lead to a territory where production facilities can be located. This two specific research questions will therefore be discussed simultaneously.

According to FAO's Statistic database (FAOSTAT 2011), there is large amounts of waste from all sources of fruit and vegetables we have listed in the chemical composition of raw materials. The waste is documented for each continent in Appendix C, *total waste globally with value calculation sorted by contients.xlsx*, and each raw material is ranked by the waste pr. country in Appendix G, *total waste from each raw material sorted by countries.xlsx*. In other words, these spread sheets show where all the waste is generated. They are unfortunately a little limited, because they don't show where in the country the waste is located and how the waste is treated. Nevertheless, it gives an indication of waste amounts by country and its availability related to quantity.

Borregaard has estimated an output of "Special" based on cellulose from wood, to approximately 30.000 tons as a total potential in target and verified market segment per year. To cover this amount with the new raw materials, we will assume that minimum 100.000 tons of waste is needed. However, the potential could be larger or less depending on the market penetration success and new market segments identified for "Special" during its market introduction. This is just an assumption because we are not able to know exactly each raw materials output and efficiency pr. kg (Heier 2011a).

The best raw material source is not necessarily *one* big source near the production facilities, since it presumably would be the best related to keep low transport costs. Borregaard preferably want different raw materials to produce "Special" because it affect the properties of the product, e.g. length of life and color. This makes it essential to combine and utilize waste from several given sources in different districts or countries, in relative nearness to the production facilities. This desire also makes the most of the sources useable because a number of sources together will cover the needed amount of input, probably some place in each continent.

The most important factor is nevertheless the cellulose content on the specific waste because it determines how much waste that is needed. Bigger sources of wastes will make it more probable to get inexpensive inputs and the grade of availability. Borregaard has mentioned that big competition of the raw materials, related to for example cattle feed or pellets for energy purposes, isn't a threat, because they have financial resources to buy the needed waste. Despite that the estimated amount of waste is calculated to approximately 100.000 tons, we will recommend location near sources that is considerably bigger. Hence, the possibility to get low prices, possible competition, requirement for more waste than calculated, and chance of inaccuracy in FAO's datasets.

5.3 Where will it be the most preferable to place the production

An important determinant factor for the production facilities is nearness to the raw material source. It's decisive because of the waste's conservability. The raw material is organic waste from fruit and vegetables and will therefore have limited length of life. When "Special" is produced the life length will increase significant and it will be possible to store the product for a longer amount of time than before the process. This will also make it possible to deliver "Special" in periods when it's off-season for the given raw material.

Another factor, from Webers approach, is transport costs. The unprocessed waste will have a higher weight than processed waste, because untreated organic waste containing a lot of water and not all of the wastes' content will be utilized. Hence, it will be more profitable to have the shortest transportation between the input source and production than the production and market. *Figure 10* is illustrating this by using Weber's location-production triangle with apple pomace and barley waste as the input sources. This case is assuming that apple pomace has a higher moisture level and mass density than barley waste, hence shorter conservability and higher weight. Therefore the d1 ought to be shorter than d2 to achieve the best spot of location related to transport costs, which contribute to maximizing of the firms' profits.

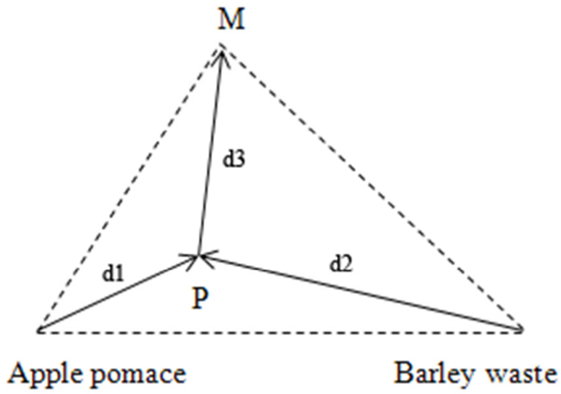


Figure 10: Best spot of production with apple pomace and barley waste as inputs (Rostad & Larsen, based on (McCann 2001: 8) localization triangle)

In the following section we're going to consider production localizations connected with waste sources. We will do different considerations between the continents.

5.3.1 Europe

There are several advantages and disadvantages by placing the production on different places. By placing the production in Europe there will be a gain to be placed inside a known market territory, near Norway. Europe is estimated as one of the biggest markets related to Borregaard's food industry and it will be strategic to have a production facility here (Heier 2011c).

Borregaard has also several existing facilities in Europe, which makes Europe preferable because of established networks, collaborating partners, logistics and knowledge about the competitors, political systems, technological- and economic factors.

Borregaard has facilities in Norway, Italy, UK, Spain, France, Sweden, Austria, Poland, and the Czech Republic in Europe, which makes a powerful network.

As mentioned Borregaard is searching for raw materials that are refined so they don't need to preprocess it before the production. Waste from pectin producers is such kind of raw material. Germany is a node for pectin production, since three of the world's six biggest pectin producers are located there. This makes Germany a very potential country for production of "Special" combined with Borregaards existing facilities, Lignotech in Karlsruhe and sales office in Düsseldorf. *Figure 11* illustrates where the biggest pectin producers in Europe are located.

Figure 11: The biggest pectin producers in Europe (Google maps 2011, modified by Rostad & Larsen)

The *table 11* from chapter 4. Findings is showing the fifteen highest waste sources in Europe and Germany is ranked as number 2, 5, and 12, with potatoes, wheat and barley. All the sources is also far above the demand of needed tons. There can also be possible to bring in waste from France, Poland, Belgium, Denmark and Italy if needed. Germany is strategically placed in the center of Europe which makes the country a node for input and output factors to the market. There is no other country in Europe that has so many obvious advantages than Germany, so we will consider the country as a good place to have production facilities.

The *figure 12* is illustrating how Germany is a node for production and distribution of "Special". According to Nordgreens list of weaknesses, the localization triangle largely involves a degree of simplifications of the real conditions. Webers theory assumes including a single market place for the manufactured products, but in the reality the products will be sold to indefinitely places. Hence it's complicated to adopt Weber's location triangle in this illustration, because we don't know exactly where in the countries the waste is located and the exact market location.

Figure 12: Germany as a node of production of special ((Blake 2011) modified by Rostad & Larsen)

So we rather illustrate the input sources with black arrows and output sources with blue arrows. Although we don't design a location triangle, Weber's theory can be adopted here, especially considered to transportation length and weight. In this case there will be most profitable to utilize raw material sources that occur in Germany or nearest the border to Germany to make the transportation costs to a minimum. There is also important to do a mapping of what conditions the waste hold, the difference by pulp, dry matter or pomace has a huge impact on the weight and bulk.

5.3.2 America

By our findings, America is superior to the amount of waste. The table below shows that Brazil is outstanding. The country is representing seven of the top fifteen sources in America.

Table 19: Top fifteen sources of waste in America (Rostad & Larsen 2011, full spread sheet on CD, Appendix D)

America			
Countries	Item	Element	2007
Brazil	Sugar Cane	Waste (tonnes)	45754340
Brazil	Maize	Waste (tonnes)	5320774
Mexico	Maize	Waste (tonnes)	3718126
Brazil	Cassava	Waste (tonnes)	2654120
Brazil	Oranges, Mandarines	Waste (tonnes)	2049810
Brazil	Rice (Paddy Equivalent)	Waste (tonnes)	1320836
United States of America	Potatoes	Waste (tonnes)	1319770
Brazil	Bananas	Waste (tonnes)	1064754
Mexico	Sugar Cane	Waste (tonnes)	1041787
Brazil	Rice (Milled Equivalent)	Waste (tonnes)	880998
United States of America	Tomatoes	Waste (tonnes)	762799
Peru	Potatoes	Waste (tonnes)	705774
Mexico	Wheat	Waste (tonnes)	643318
Argentina	Wheat	Waste (tonnes)	581638
Peru	Plantains	Waste (tonnes)	574928

By being so remarkable, Brazil is absolutely a good alternative for placing production of "Special". It's a country where huge amounts of waste are generated from different resources with high content of cellulose, like sugar cane, maize, rice and banana.
Brazil is one of the major producers of bioethanol in the world and produced 6,921.54 millions of gallons in 2010 (Renewable Fuels Association 2010). Scientist at Borregaard has mentioned that processed waste after bioethanol production probably will be useable for production of "Special" and therefore mentions Brazil as a very relevant location.

Borregaard has also a production facility in Brazil, LignoTech in São Paulo, which is a highly positive factor for a new establishment, like in Europe.

An optimal place of Borregaards industrial location in Brazil would be in proximity to their existing facilities combined with bioethanol- and pectin producers. Such composition will probably ensure agglomeration economies, like supply of relevant resources like high suitable raw materials, established infrastructure and competence sharing.

The biggest market for today's "Special" is North America. A production facility in at the same continent is therefore preferable, although it's a distance from south to north, but it's cheaper than transporting "Special" overseas from Europe.

5.3.3 Asia

According to table 13 from chapter 4, China and India has significant amounts of waste. The amounts are satisfactorily, but we don't consider China and India as equally relevant as previous destinations. Borregaard has sales offices in both countries, but no present production facilities, hence it may lead to establishments from scratch, which is an enormous investment. They are both big countries with large distances, and especially China is divided into provinces, which *possibly* results in transport barriers between them (Heier 2011c).

China's enormous area will require a huge analysis of geographical-, political-, economical- and technological factors before a potential decision can be taken. A beginning is to start to communicate with Andre Pectin which is one of the world's biggest pectin producers located in China. Waste collaboration with Andre Pectin can therefore be an access key for production facilities in Asia.

A positive factor regarding localization in China or India is low labour costs (Statistisk sentralbyrå 2008), which is one of Alfred Weber's main determinants that influence the perfect spot of location. However, a lot of other determinant factors is unknown compared to other continents and an establishment in China will therefore be more extensive and costly compared to e.g. Europe.

A concern connected to China and India is the degree of poverty. In India about 100 to 150 millions of people are suffering of poverty. If India develop the infrastructure, the intake to the industry and at the same time manage their enormous human resources there will be more likely to establish a production facility there in the future (Statistisk sentralbyrå 2008).

5.3.4 Africa

Africa unfortunately shares some of the same weaknesses as China and India. Networks of roads, transport and necessarily infrastructure is very poor (Store Norske Leksikon 2011). The political condition in several African countries is far from good and big parts of Africa are

lacking democracy and political stability. Regimes and frequently political power shifts, often during military influence has been the reality (Store Norske Leksikon 2011).
Nigeria is a rich country in terms of raw materials and has a lot of waste with average good chemical composition. The West African country could be a possible place of location, but like many other African countries, Nigeria has suffered from corruption problems, inadequate infrastructure, and political instability, though this has improved the last years (Central Intelligence Agency 2011). In this continent a lot of the determinant factors of location like technological- and political factors are lacking and such circumstances are not adequate for an industrial placing. According to Per-Ivar Heier at Borregaard, it's not of current interest to establish in a country with political turbulence, but Africa can be of interest later, if the circumstances getting better.

Table 20: Top fifteen sources of waste in Africa (Rostad & Larsen 2011, full spread sheet on CD, Appendix D)

Africa			
Countries	Item	Element	2007
Nigeria	Cassava	Waste (tonnes)	4979995
Nigeria	Yams	Waste (tonnes)	3113600
Ghana	Cassava	Waste (tonnes)	2896412
Angola	Cassava	Waste (tonnes)	1120000
Nigeria	Sorghum	Waste (tonnes)	1034631
South Africa	Sugar Cane	Waste (tonnes)	986200
Egypt	Maize	Waste (tonnes)	932612
Egypt	Wheat	Waste (tonnes)	887863
United Republic of Tanzania	Bananas	Waste (tonnes)	875000
Egypt	Tomatoes	Waste (tonnes)	863902
Nigeria	Sugar Cane	Waste (tonnes)	753810
Nigeria	Maize	Waste (tonnes)	750987
Nigeria	Sweet Potatoes	Waste (tonnes)	729600
Uganda	Plantains	Waste (tonnes)	700000
Côte d'Ivoire	Yams	Waste (tonnes)	584221

6. Conclusion

In this chapter all the findings and the discussion will be brought to an end with conclusions, answering the 3 research questions, which in total answer the key research question.

These conclusions are meant to show the results of the study and give advices for the project's future. Most of these conclusions are made knowing that more research should be done before choosing raw materials and location, and will be preliminary conclusions until further research is done. The second part of the chapter will clarify all further research that should be done before making final decisions on choice of raw materials and location of a new production site.

6.1 Conclusion

The first conclusion that needs to be done is the answer of Q1: "*Which raw materials are best suited for the production?*".

Borregaard is not seeking to find just one raw material, but probably several, in order to get several products with different properties. The answer also depends on if the application needs a super clean raw material or not.

Maize/corn is without a doubt the raw material with the highest cellulose content, but with a medium amount of hemicellulose it needs to be tested to make sure that it will be suited for the process. If it fits the process, it will probably be the raw material with the highest output. If a super clean raw material is not needed, in addition to maize, the top 5 of best suited raw materials for the production will be *apple, sugar cane, wheat and rice*.

Furthermore we will advise Borregaard to look further into the raw materials used in pectin production in order to get super clean raw materials if this is needed for the process. Raw materials like citrus fruits and apples are often used for pectin production and will result in residues that are well suited for the process making "Special". If preprocessed, the following raw materials are the top 5: *Maize, banana, lemon, grapefruit* and *orange*. These raw materials will give possibly high output and be easy to process. Moreover, buying the raw materials after the pectin extraction will probably give a lower cost than trying to compete on price with the pectin producers. Apples, as mentioned, are often used in pectin production and could be suitable for the process, but because of higher amounts of hemicellulose the others mentioned in top 5 seems to fit the process better.

Barley and Sorghum might possibly get into top 5 of one or both of these lists, depending on test results on hemicelluloses in sorghum and lignin content in barley. This study did unfortunately not find these amounts through the research. Mustard seed and sunflower seed would also fit the process as well as the last mentioned top 5, but because of lower waste volumes around the world than the others, they don't make it into top 5. This brings us to the second conclusion, which is answering Q2: "*Which raw material sources are available, and where are they located?"*.

There's a lot of waste from fruit and vegetable production around the world. All the 30 raw materials mentioned in this study have big volumes of waste in all continents except in Oceania. The 5 raw materials with the most waste in the world are *sugar cane, rice, maize, potato* and *cassava*. Looking further into the sources' location by countries shows that the 3 biggest waste sources in Europe are *potatoes*, *wheat* and *maize.* Germany, Poland and Ukraine have high volumes of waste from several of the raw materials, but the volumes are generally much more equal from country to country than in the other continents. One other positive aspect of Germany is that 3 of the 4 biggest pectin producers in the world are located there.

In America *sugar cane, maize* and *cassava* are at the top 3 in volumes, and Brazil and Mexico have much waste from several raw materials. Brazil is nevertheless the country with the absolutely highest volumes from many of the raw materials. The world's biggest pectin producer is located in Brazil and the second largest is situated in Mexico. Brazil is also the second largest producer of ethanol in the world. Sugar cane is mostly used for the ethanol production, and waste from this production can be reused for production of "Special".

The top 3 sources in volume in Asia are *rice (milled), rice (paddy)* and *potatoes*. In Asia, China and India have the biggest volumes of waste from production of fruit and vegetables.

Nigeria is the country in Africa with the most waste, but Egypt also has big volumes. In Africa in total the top 3 volumes of waste are *cassava, yams* and *maize.*

Finding the available raw materials and where they are located shapes the background for Q3: "*Where will it be the most preferable to place the production?*"

Because of weight before and after the production process of "Special", it will be preferable to locate the production close to the waste/input source taking the transport costs into consideration. The short life length of the waste will also make it difficult to locate far from the waste. After the process the life length will increase a lot and be possible to store the product for a longer amount of time than before the process.

Borregaard wants a location with availability of several raw materials. Countries with high volumes of waste from several raw materials will therefore be the most interesting. Location near waste from pectin producers will also give possibilities for getting a cleaner raw material and access to infrastructures.

The countries fitting this description the best are Germany, Brazil, Nigeria and China, representing one continent each. Taking more localization factors into consideration like political, economic, social and technological factors Germany and Brazil are the two most preferable locations for production of "Special". Nigeria has suffered from corruption problems and inadequate infrastructure, and political instability, though this has improved the last years. In China the markets are widespread over the huge country making it more difficult to find a perfect location. Borregaard doesn't have any production facilities in China or Nigeria either and have to start from scratch if China or Nigeria is chosen as location. The distance from Borregaard's home markets in Europe and America is also negative. Germany and Brazil, on the other hand, doesn't suffer from any of such problems. In these two countries Borregaard will have access to huge amounts of several raw materials. Probably also waste from pectin production and access to good infrastructures. In addition Borregaard has other production facilities in Germany and Brazil and know these countries and their way of business very well. This will minimize some of the risks of starting production in other countries.

The fact that Borregaard preferably wants to start up production in Europe before expanding to other countries and continents, makes Germany the most preferable location overall, and the country we advise to look further into and start production in. After some time of producing in Germany getting more experience and knowledge it will be advisable to consider starting production in other countries, like Brazil.

6.1 Further research

With this study Borregaard hopefully have a good basis and will get a good start on the rest of the project. The research has shown a lot of results, but some further research needs to be done in order to implement the project.

First, it would be wisely to test some raw materials in a lab or pilot plant to assure the suitability. This way Borregaard can achieve 100% correct results on chemical contents and suitability for this exact purpose. This will also give an aspect on the outcome and possible earnings per/kg raw material. Testing the raw materials will also give answers to whether it is possible to mix different raw materials with each other or not. Borregaard has a hypothesis that different raw materials will give different outputs with different properties, and therefore possibilities of mixing raw materials together. If this is possible it will be possible to make a wide range of products to several markets. In addition to this it's important for the further research to test the moisture content of the raw materials and also season variations and conservability. If the raw material doesn't last for a certain period, it has to be processed within a certain time. This could potentially give problems regarding storage and transport.

Second, the further research should look further into some of the countries, for instance Germany and Brazil. It will be important to know if the waste volumes are from many small locations or from a few larger ones. Information whether there are any assemblage points, and how the logistics in the given locations are, should be examined. Many small sources could give high transport costs compared to a few larger sources. The rights for the waste must also be clarified to make sure that Borregaard are even allowed to buy the raw materials and use them for production. Borregaard also need to check what is done to the waste and what it's used for as of to prevent getting surprised by competition from other buyers.

Third, we recommend Borregaard to go further on contacting pectin producers, and fruit and vegetable producers. We have already been in contact with many producers around the world. Going further and suggesting a possible cooperation or some other deal might give more correct and deeper information about the companies' waste. This will be a crucial aspect for deciding location of the production. We have contact information and copies of the emails to all the producers and organizations we have contacted and talked to and it will be easy to get in contact with the right persons at the companies around the world.

Fourth, one of the most important points of further research will be to analyse all aspects of location. After getting better contact with possible suppliers of raw materials, it will be very important to analyse all the factors affecting the location of production near each supplier. This means going further in research and reveal all location factors at the given location such as factors of political risks and economy. Degree of bureaucracy, corruption risk, rule of law, tax levels, culture, season variations, logistics, labour costs, land prices, construction prices, access to knowledge, and proximity to innovation environments (clusters). These are all factors that in total will affect the total profit of choosing a location over another. In other words: a more qualitative and deeper research of the given locations, which are under consideration, should be done.

Appendices

Appendix A - Chemical composition of raw materials.xlsx

This appendix is too big to implement in this document, see the attached CD.

Appendix B - Communication list

Inbox			
No.	*From*	*Received*	*Subject*
1.	*torkel.ystgaard@siva.no*	Apr 13, 2011	Re: Masteroppgave lokalisering
2.	*Gjert Melsom. Ernst&Young*	Apr 7, 2011	Re: FWD: Hendvendelse
3.	*Hoejgaard Christensen, Steen*	Mar 30, 2011	RE: Pectin
4.	*Endreß Prof. Dr., Hans-Ulrich*	Mar 29, 2011	AW: WG: Pectin
5.	*Endreß Prof. Dr., Hans-Ulrich*	Mar 29, 2011	WG: Pectin
6.	*Hoejgaard Christensen, Steen*	Mar 28, 2011	RE: Pectin
7.	*Ross Campbell*	Mar 25, 2011	RE: [Fwd: FW: Alt raw materials study - supporting ...
8.	*Rune Buvarp*	Mar 18, 2011	Re: Dyrefor og verdibetraktninger
9.	*Rune Buvarp*	Mar 15, 2011	Rune Buvarp/NO_SPG/Borregaard/ODIN is out of the o...
10.	*Knut Røflo*	Mar 15, 2011	SV: SV: Protein price.xlsx
11.	*Knut Røflo*	Mar 14, 2011	SV: Protein price.xlsx
12.	*Ross Campbell*	Mar 11, 2011	RE: [Fwd: FW: Alt raw materials study - supporting ...
13.	*Ross Campbell*	Mar 9, 2011	FW: Alt raw materials study - supporting students
14.	*kevinphilp*	Mar 8, 2011	RE: [Fwd: Alt raw materials study - supporting stu...
15.	*kevinphilp*	Mar 8, 2011	RE: [Fwd: Alt raw materials study - supporting stu...
16.	*Ross Campbell*	Mar 8, 2011	RE: [Fwd: Alt raw materials study - supporting stu...
17.	*Knut Røflo*	Mar 8, 2011	SV: VS: Råvarepriser fra Oil World
18.	*Meeuwissen, Corne*	Mar 8, 2011	RE: Waste from fruit and vegetable processing
19.	*Schlagitweit*	Mar 8, 2011	Re: Pellets price index
20.	*Knut Røflo*	Mar 7, 2011	VS: Råvarepriser fra Oil World
21.	*Knut Røflo*	Mar 7, 2011	SV: Råvarepriser
22.	*ask-fao@fao.org*	Mar 7, 2011	Ask FAO: Your question has been received. Please c...
23.	*Knut Røflo*	Mar 1, 2011	Råvarepriser
24.	*Tore Filbakk*	Feb 24, 2011	SV: Pellets

25.	*dagfinn*	Feb 23, 2011	SV: Pellets
26.	*Kris Bevill*	Feb 22, 2011	RE: Bioethanol from citrus waste
27.	*Rune Buvarp*	Feb 22, 2011	Re: Dyrefor og verdibetraktninger
28.	*Kallio Markku*	Feb 22, 2011	RE: Pellets price index
29.	*Bøeng, Ann Christin*	Feb 22, 2011	SV: [Ticket#20110221118310] Forespørsel SSB
30.	*Schlagitweit*	Feb 22, 2011	Re: Pellets price index
31.	*Morten Tony Hansen*	Feb 21, 2011	RE: Pellets price index
32.	*Christophe BAREL/ADEME*	Feb 21, 2011	RE: Pellets price index
33.	*Morten Tony Hansen*	Feb 21, 2011	Pellets price index
34.	*PROFEL*	Feb 21, 2011	RE: [Fwd: master thesis about waste from fruit and ...
35.	*Simen Gjølsjø*	Feb 21, 2011	SV: Pellets
36.	*Lars Sørum*	Feb 20, 2011	RE: Pellets
37.	*ostgaard*	Feb 18, 2011	Re: Pellets
38.	*Jorunn Skjermo*	Feb 18, 2011	RE: Pellets
39.	*media@eufic.org*	Feb 17, 2011	How do consumers respond to portion information on...
40.	*Petter H Heyerdahl*	Feb 16, 2011	RE: Bioetanol
41.	*Svein Jarle Horn*	Feb 14, 2011	SV: Bioetanol
42.	*Petter H Heyerdahl*	Feb 14, 2011	RE: Bioetanol
43.	*Europe Direct*	Feb 3, 2011	[Case_ID: 0350311 / 8113231] master thesis about f...
44.	*FRESHFEL EUROPE*	Feb 3, 2011	Re: master thesis about waste from fruit and veget...
45.	*Klaus Heitlinger*	Feb 3, 2011	AW: Pomace and peels; Your email of 21th Jan. 2011
46.	*Dietz International Info*	Jan 31, 2011	AW: Pomace and peels
47.	*Larissa Popp*	Jan 28, 2011	RES: RES: Pomace and peels
48.	*Berit Karoline Martinsen*	Jan 28, 2011	Re: Datasett
49.	*Magnor Kåre Hansen*	Jan 28, 2011	RE: Kontaktperson
50.	*Klaus Heitlinger*	Jan 28, 2011	Pomace and peels; Your email of 21th Jan. 2011
51.	*Grete Skrede*	Jan 28, 2011	Fw: Vs: Fiber
52.	*Siv Fagertun Remberg*	Jan 28, 2011	Re: Kontaktperson

53.	*European Food SCP*	Jan 28, 2011	RE: master thesis about use of waste from fruits a...
54.	*Europebranch*	Jan 28, 2011	RE: master thesis about waste from fruits and vege...
55.	*media@eufic.org*	Jan 27, 2011	Your Expert Contact Centre registration confirmati...
56.	*eufic@eufic.org*	Jan 27, 2011	Expert contact center registration request
57.	*Matportalen*	Jan 27, 2011	SV: Fiber
58.	*Klaus Fottland*	Jan 27, 2011	Vedr. Anmodning om opplysninger - Clean Label begr...
59.	*Simon Ballance*	Jan 27, 2011	Re: Fw: Vs: Fiber
60.	*Larissa Popp*	Jan 27, 2011	RES: Pomace and peels
61.	*Kikoula Cotsapas*	Jan 27, 2011	RE: Pomace and peels
62.	*Philip Springuel*	Jan 26, 2011	RE: [NEWSENDER] - master thesis about waste from f...
63.	*no_reply@edcc.ec.europa.eu*	Jan 26, 2011	[Case_ID: 0350311 / 2113285] - master thesis about ...
64.	*Anne-Berit Wold*	Jan 26, 2011	RE: Kontaktperson
65.	*Lena Straume*	Jan 26, 2011	Vs: Studentoppgave
66.	*karin.batstra@aijn.org*	Jan 26, 2011	RE: Pomace and peels from juice- and concentrate p...
67.	*karin.batstra@aijn.org*	Jan 26, 2011	RE: Pomace and peels from juice- and concentrate p...
68.	*Trude Wicklund*	Jan 26, 2011	FW: Kontaktperson
69.	*milica trbojevic*	Jan 26, 2011	RE: Pomace and peels from juice- and concentrate p...
70.	*Grupo de Consultores em Citros*	Jan 25, 2011	Retorno Automático Grupo de Consultores em Citros
71.	*Evi Brennich*	Jan 25, 2011	Pomace and Peels - confructa medien GmbH
72.	*servizio consumatori*	Jan 25, 2011	Pomace and peels
73.	*tfs@tine.no*	Jan 25, 2011	Svar: Pressrester og avfall
74.	*Anderson,Jennifer*	Jan 24, 2011	RE: Dietary Fiber
75.	*Corbett, Brandon*	Jan 24, 2011	RE: Pomace and peels
76.	*terje.bleie@no.findus.com*	Jan 24, 2011	Ad: Vs: Fw: Kartlegging av pressrester og fruktavf...
77.	*Behringer, Armin*	Jan 24, 2011	AW: Pomace and peels
78.	*info@dietz-international.de*	Jan 23, 2011	Re: Pomace and peels
79.	*Miladin Sevarlic*	Jan 22, 2011	Re: Pomace and peels
80.	*Bunning,M.*	Jan 22, 2011	RE: Dietary Fiber

81.	*lars-ivar.kjaer@no.findus.com*	Jan 21, 2011	Vs: Fw: Kartlegging av pressrester og fruktavfall
82.	*sentralbord@no.findus.com*	Jan 21, 2011	Ad: epost adresser
83.	*Konsumentkontakt@no.findus.com*	Jan 20, 2011	Re: Kontaktinformasjon
84.	*sentralbord@no.findus.com*	Jan 20, 2011	Ad: Re: Ad: Kontaktinformasjon
85.	*sentralbord@no.findus.com*	Jan 20, 2011	Ad: Kontaktinformasjon
86.	*Kai Brandstorp*	Jan 20, 2011	SV: Kartlegging av pressrester
87.	*Astrid Lier Rømuld*	Jan 18, 2011	SV: Pressrester
88.	*guenther.laufenberg@bayer.com*	Jan 17, 2011	use of waste from fruit and vegetable production, ...
89.	*Rune Bakke*	Jan 17, 2011	Re: Pressrester og avfall fra frukt og grønnsaker
90.	*Bjørge Westereng*	Jan 16, 2011	SV: Kontaktperson
91.	*Anderson,Jennifer*	Jan 15, 2011	Re: Dietary Fiber
92.	*Elisabeth Fjærvoll Olsen*	Jan 14, 2011	RE: Kontaktperson
93.	*Gunhild Akervold Dalen*	Jan 14, 2011	Fw: Vs: Clean Label
94.	*Anderson,Jennifer*	Jan 13, 2011	Re: Dietary Fiber
95.	*Epleblomsten v/ Britt Sauar*	Jan 13, 2011	SV: Fruktavfall og pressrester
96.	*Stavland Hermetikk AS*	Jan 13, 2011	SV: Pressrester og avfall
97.	*Hardanger saft og Siderfabrikk AS*	Jan 12, 2011	SV: Fruktavfall og pressrester
98.	*Inger Grøttum*	Jan 12, 2011	Avfall
99.	*sissel.orring@stabburet.no*	Jan 12, 2011	Ad: Saksnummer. # WEB-615: Avfall og pressrester p...
100.	*Astrid Lier Rømuld*	Jan 11, 2011	Pressrester
101.	*Jens Strøm*	Jan 11, 2011	VS: Fruktavfall og pressrester
102.	*sissel.orring@stabburet.no*	Jan 11, 2011	Ad: Saksnummer. # WEB-615: Avfall og pressrester p...
103.	*forbrukerservice@stabburet.no*	Jan 11, 2011	Kontakt Stabburet - kvitteringsepost - 31207
104.	*Oddmund Østebø*	Jan 11, 2011	SV: Frukt.no: Skjema -
105.	*Matportalen*	Jan 11, 2011	SV: Clean Label

	Sent folder		
No.	*To*	*Sent*	*Subject*
1.	*torkel.ystgaard@siva.no*	Apr 13, 2011	Re: Masteroppgave lokalisering
2.	*torkel.ystgaard@siva.no*	Apr 6, 2011	Masteroppgave lokalisering
3.	*ingunn.baretto@giek.no*	Apr 6, 2011	Masteroppgave lokalisering
4.	*Hoejgaard Christensen, Steen*	Mar 29, 2011	RE: Pectin
5.	*"Endreß Prof. Dr., Hans-Ulrich"*	Mar 29, 2011	Re: WG: Pectin
6.	*"Endreß Prof. Dr., Hans-Ulrich"*	Mar 29, 2011	Re: WG: Pectin
7.	*Schmitt, Christine*	Mar 29, 2011	Re: AW: master thesis
8.	*info@jrs.de*	Mar 28, 2011	master thesis
9.	*secretary-general@ippa.info*	Mar 28, 2011	Master thesis
10.	*Ross Campbell*	Mar 28, 2011	RE: [Fwd: FW: Alt raw materials study - supporting ...
11.	*faostat-inquiries@fao.org*	Mar 28, 2011	Statistics for master thesis
12.	*jakob.lundberg@fao.org*	Mar 28, 2011	Statistikk til masteroppgave
13.	*FAO-HQ@fao.org*	Mar 28, 2011	Master thesis
14.	*executive-secretary@ippa.info*	Mar 28, 2011	Pectin
15.	*b.lundberg@fiberstar.net*	Mar 28, 2011	Pectin
16.	*info@herbstreith-fox.de*	Mar 28, 2011	Pectin
17.	*info@herbafood.de*	Mar 28, 2011	Pectin
18.	*Ross Campbell*	Mar 24, 2011	RE: [Fwd: FW: Alt raw materials study - supporting ...
19.	*Rune Buvarp*	Mar 15, 2011	Re: Dyrefor og verdibetraktninger
20.	*"Knut Røflo"*	Mar 15, 2011	Re: SV: Protein price.xlsx
21.	*Ross Campbell*	Mar 11, 2011	RE: [Fwd: FW: Alt raw materials study - supporting ...
22.	*campbell.rh@gmail.com*	Mar 11, 2011	[Fwd: FW: Alt raw materials study - supporting stu...
23.	*"Knut Røflo"*	Mar 10, 2011	Re: SV: VS: Råvarepriser fra Oil World
24.	*Ross Campbell*	Mar 9, 2011	RE: [Fwd: Alt raw materials study - supporting stu...
25.	*kevinphilp*	Mar 8, 2011	RE: [Fwd: Alt raw materials study - supporting stu...

26.	*ross@cybercolloids.net*	Mar 8, 2011	[Fwd: Alt raw materials study - supporting student...
27.	*"Knut Røflo"*	Mar 8, 2011	Re: VS: Råvarepriser fra Oil World
28.	*corne.meeuwissen@cosun.com*	Mar 8, 2011	Waste from fruit and vegetable processing
29.	*Schlagitweit*	Mar 8, 2011	Re: Pellets price index
30.	*"Knut Røflo"*	Mar 7, 2011	Re: Råvarepriser
31.	*ross@cybercolloids.net*	Mar 3, 2011	Alt raw materials study - supporting students
32.	*kari.ljokjel@fkf.no*	Mar 1, 2011	Prisdrivere dyrefôr
33.	*doug@surialink.com*	Feb 24, 2011	Seaweed overview
34.	*david@surialink.com*	Feb 24, 2011	Seaweed overview
35.	*contact@surialink.com*	Feb 24, 2011	Seaweed overview
36.	*info@surialink.com*	Feb 24, 2011	Seaweed overview
37.	*Kris Bevill*	Feb 24, 2011	RE: Bioethanol from citrus waste
38.	*Schlagitweit*	Feb 22, 2011	Re: Pellets price index
39.	*kbevill@bbibiofuels.com*	Feb 21, 2011	Bioethanol from citrus waste
40.	*wolfgang.hiegl@wip-munich.de*	Feb 21, 2011	Pellets price index
41.	*granupro@bioenergie-promotion.fr*	Feb 21, 2011	Pellets price index
42.	*SNPGB@fnbois.com*	Feb 21, 2011	Pellets price index
43.	*c.greinoecker@holzforschung.at*	Feb 21, 2011	Pellets price index
44.	*markku.kallio@vtt.fi*	Feb 21, 2011	Pellets price index
45.	*c.greinoecker@holzforforschung.at*	Feb 21, 2011	[Fwd: Pellets price index]
46.	*christophe.barel@ademe.fr*	Feb 21, 2011	Pellets price index
47.	*sandra.hayes@nef.org.uk*	Feb 21, 2011	Pellets price index
48.	*bape@bape.com.pl*	Feb 21, 2011	Pellets price index
49.	*alexander.hoeldrich@wip-munich.de*	Feb 21, 2011	Pellets price index
50.	*mth@force.dk*	Feb 21, 2011	Pellets price index
51.	*pfimail@pelletheat.org*	Feb 21, 2011	Pellets price index
52.	*schlagitweit@propellets.at*	Feb 21, 2011	Pellets price index
53.	*tore.filbakk@skogoglandskap.no*	Feb 21, 2011	Pellets

54.	*simen.gjolsjo@skogoglandskap.no*	Feb 21, 2011	Pellets
55.	*dagfinn@stoker.no*	Feb 18, 2011	Pellets
56.	*post@biobrensel.no*	Feb 18, 2011	Pellets
57.	*Jorunn.Skjermo@sintef.no*	Feb 18, 2011	Pellets
58.	*ostgaard@biotech.ntnu.no*	Feb 18, 2011	Pellets
59.	*morten.gronli@ntnu.no*	Feb 18, 2011	Pellets
60.	*lars.sorum@sintef.no*	Feb 18, 2011	Pellets
61.	*corne.meeuwissen@cosun.com*	Feb 18, 2011	Waste from fruit and vegetable processing
62.	*Svein Jarle Horn*	Feb 16, 2011	Re: SV: Bioetanol
63.	*profel@agep.eu*	Feb 16, 2011	[Fwd: master thesis about waste from fruit and veg...
64.	*Petter H Heyerdahl*	Feb 14, 2011	RE: Bioetanol
65.	*svein.horn@umb.no*	Feb 14, 2011	Bioetanol
66.	*Petter H Heyerdahl*	Feb 14, 2011	Bioetanol
67.	*profel@agep.eu*	Feb 3, 2011	master thesis about waste from fruit and vegetable ...
68.	*FRESHFEL EUROPE*	Feb 3, 2011	Re: master thesis about waste from fruit and veget...
69.	*info@freshfel.org*	Feb 3, 2011	master thesis about waste from fruit and vegetable ...
70.	*firmapost@groindustrier.no*	Feb 3, 2011	Pressrester
71.	*Kikoula Cotsapas*	Feb 1, 2011	RE: Pomace and peels
72.	*skip@shapiroe.com*	Feb 1, 2011	Pomace and peels
73.	*info@dwv-online.de*	Feb 1, 2011	Pomace and peels
74.	*Klaus Heitlinger*	Feb 1, 2011	Re: Pomace and peels; Your email of 21th Jan. 2011
75.	*Berit Karoline Martinsen*	Feb 1, 2011	Re: Datasett
76.	*Larissa Popp*	Feb 1, 2011	Re: RES: RES: Pomace and peels
77.	*info@possmann.de*	Feb 1, 2011	Pomace and peels
78.	*Berit Karoline Martinsen*	Jan 28, 2011	Datasett
79.	*Klaus Fottland*	Jan 28, 2011	Re: Vedr. Anmodning om opplysninger - Clean Label ...
80.	*Siv Fagertun Remberg*	Jan 28, 2011	Re: Kontaktperson
81.	*Grete Skrede*	Jan 28, 2011	Re: Fw: Vs: Fiber

82.	*Larissa Popp*	Jan 27, 2011	Re: RES: Pomace and peels
83.	*Anne-Berit Wold*	Jan 27, 2011	RE: Kontaktperson
84.	*ole_jorgen.hanssen@umb.no*	Jan 26, 2011	Fiber
85.	*matport@mattilsynet.no*	Jan 26, 2011	Fiber
86.	*mat@nofima.no*	Jan 26, 2011	Fiber
87.	*post.st@nofima.no*	Jan 26, 2011	GIATH
88.	*ingrediens@nofima.no*	Jan 26, 2011	Fiber
89.	*nofima@nofima.no*	Jan 26, 2011	Fiber
90.	*anne-berit.wold@umb.no*	Jan 26, 2011	Kontaktperson
91.	*siv.remberg@umb.no*	Jan 26, 2011	Kontaktperson
92.	*ciaa@ciaa.eu*	Jan 26, 2011	master thesis about waste from fruits and vegetabl...
93.	*info@ilsi.org*	Jan 26, 2011	master thesis about waste from fruits and vegetabl...
94.	*philip.springuel@eufic.org*	Jan 26, 2011	master thesis about waste from fruits and vegetabl...
95.	*FAO-HQ@fao.org*	Jan 26, 2011	[Fwd: master thesis about waste from fruits and ve...
96.	*ifu@ifu-fruitjuice.com*	Jan 26, 2011	[Fwd: master thesis about waste from fruits and ve...
97.	*milica trbojevic*	Jan 26, 2011	RE: Pomace and peels from juice- and concentrate p...
98.	*karin.batstra@aijn.org*	Jan 26, 2011	RE: Pomace and peels from juice- and concentrate p...
99.	*Magnor Kåre Hansen*	Jan 26, 2011	Kontaktperson
100.	*karin.batstra@aijn.org*	Jan 26, 2011	Pomace and peels from juice- and concentrate produ...
101.	*Trude Wicklund*	Jan 26, 2011	Re: FW: Kontaktperson
102.	*Evi Brennich*	Jan 25, 2011	Re: Pomace and Peels - confructa medien GmbH
103.	*general@brazilgourmet.com*	Jan 25, 2011	Pomace and peels
104.	*socitrus@yahoo.com.br*	Jan 25, 2011	Pomace and peels
105.	*fpdc@fundecitrus.com.br*	Jan 25, 2011	Pomace and peels
106.	*advertise@juicybrazil.com*	Jan 25, 2011	Pomace and peels
107.	*shirley.perryman@colostate.edu*	Jan 25, 2011	Dietary Fiber
108.	*servizioconsumatori@ccci.it*	Jan 25, 2011	Pomace and peels
109.	*conserveitalia@ccci.it*	Jan 25, 2011	Pomace and peels

110.	*firmapost@tine.no*	Jan 25, 2011	Pressrester og avfall
111.	*zisaft@zipperle.it*	Jan 24, 2011	Pomace and peels from juice- and concentrate produ...
112.	*info@dietz-international.de*	Jan 24, 2011	Re: Pomace and peels
113.	*milica.jevtic@aijn.org*	Jan 24, 2011	Pomace and peels from juice- and concentrate produ...
114.	*Miladin Sevarlic*	Jan 24, 2011	Re: Pomace and peels
115.	*firmapost@groindustrier.no*	Jan 24, 2011	Pressrester
116.	*Bunning,M.*	Jan 24, 2011	RE: Dietary Fiber
117.	*jpa@kellencompany.com*	Jan 22, 2011	Pomace and peels
118.	*milsevar@eunet.rs*	Jan 22, 2011	Pomace and peels
119.	*chinajuice@cccfna.org.cn*	Jan 22, 2011	Pomace and peels
120.	*meyed@meyed.org.tr*	Jan 22, 2011	Pomace and peels
121.	*rsps@rsps.ru*	Jan 22, 2011	Pomace and peels
122.	*info@rsps.ru*	Jan 22, 2011	Pomace and peels
123.	*armin.behringer@wild.de*	Jan 22, 2011	Pomace and peels
124.	*pirella@t-com.me*	Jan 22, 2011	Pomace and peels
125.	*marc_deschrijver@eu.dole.com*	Jan 22, 2011	Pomace and peels
126.	*kees.cools@doehler.com*	Jan 22, 2011	Pomace and peels
127.	*info@bucherunipektin.com*	Jan 22, 2011	Pomace and peels
128.	*Hartmut Haverland*	Jan 22, 2011	Pomace and peels
129.	*jardagh@britishsoftdrinks.com*	Jan 21, 2011	Pomace and peels
130.	*peter.wannding@li.se*	Jan 21, 2011	Pomace and peels
131.	*bsda@britishsoftdrinks.com*	Jan 21, 2011	Pomace and peels
132.	*secretaria@zumosdefrutas.org*	Jan 21, 2011	Pomace and peels
133.	*asozumos@asozumos.org*	Jan 21, 2011	Pomace and peels
134.	*anirsf@netcabo.pt*	Jan 21, 2011	Pomace and peels
135.	*biuro@kups.org.pl*	Jan 21, 2011	Pomace and peels
136.	*stondini@ccci.it*	Jan 21, 2011	Pomace and peels
137.	*conserveitalia@ccci.it*	Jan 21, 2011	Pomace and peels

138.	*federvini@foodarea.it*	Jan 21, 2011	Pomace and peels
139.	*f.peron@aiipa.it*	Jan 21, 2011	Pomace and peels
140.	*info@beveragecouncilofireland.ie*	Jan 21, 2011	Pomace and peels
141.	*sinead@beveragecouncilofireland.ie*	Jan 21, 2011	Pomace and peels
142.	*info@fruchtsaft.net*	Jan 21, 2011	Pomace and peels
143.	*sennewald@fruchtsaft.org*	Jan 21, 2011	Pomace and peels
144.	*fruchtsaftverband@gmx.de*	Jan 21, 2011	Pomace and peels
145.	*unijus@unijus.org*	Jan 21, 2011	Pomace and peels
146.	*jantoine.unijus@wanadoo.fr*	Jan 21, 2011	Pomace and peels
147.	*elisa.piesala@etl.fi*	Jan 21, 2011	Pomace and peels
148.	*gh@di.dk*	Jan 21, 2011	Pomace and peels
149.	*kean@keanltd.com.cy*	Jan 21, 2011	Pomace and peels
150.	*kikoula@keanltd.com.cy*	Jan 21, 2011	Pomace and peels
151.	*nadia.lapage@ajunec.be*	Jan 21, 2011	Pomace and peels
152.	*getraenke@dielebensmittel.at*	Jan 21, 2011	Pomace and peels
153.	*Kai Brandstorp*	Jan 21, 2011	Re: SV: Kartlegging av pressrester
154.	*jan.hermans@aijn.org*	Jan 21, 2011	Pomace and peels
155.	*info@sgf.org*	Jan 21, 2011	Pomace and peels
156.	*aijn@aijn.org*	Jan 21, 2011	Pomace and peels
157.	*info@fruit-processing.com*	Jan 21, 2011	Pomace and peels
158.	*info@dietz-international.de*	Jan 21, 2011	Pomace and peels
159.	*citrusbr@citrusbr.com*	Jan 21, 2011	Pomace and peels
160.	*firmapost@groindustrier.no*	Jan 21, 2011	Pressrester
161.	*post@no.findus.com*	Jan 21, 2011	Kartlegging av pressrester og fruktavfall
162.	*info@food-scp.eu*	Jan 21, 2011	master thesis about use of waste from fruits and v...
163.	*info@ift.org*	Jan 21, 2011	master thesis about waste from fruits and vegetabl...
164.	*Reed.Blauer@fas.usda.gov*	Jan 20, 2011	waste from fruits and vegetables
165.	*FAO-HQ@fao.org*	Jan 20, 2011	master thesis about waste from fruits and vegetabl...

166.	*ess-registry@fao.org*	Jan 20, 2011	master thesis about waste from fruits and vegetabl...
167.	*info@eckes-granini.com*	Jan 20, 2011	master thesis about waste from fruits and vegetabl...
168.	*info@juiceworld.net*	Jan 20, 2011	Master thesis about waste from fruits and vegetabl...
169.	*nadine.schulze@uni-bonn.de*	Jan 20, 2011	[Fwd: use of waste from fruit and vegetable produc...
170.	*post@no.findus.com*	Jan 20, 2011	epost adresser
171.	*zuvamesa@zuvamesa.com*	Jan 20, 2011	Zuvamesa juice plant
172.	*sentralbord@no.findus.com*	Jan 20, 2011	Re: Ad: Kontaktinformasjon
173.	*firmapost@groindustrier.no*	Jan 20, 2011	Pressrester
174.	*post@no.findus.com*	Jan 20, 2011	Kontaktinformasjon
175.	*konsumentkontakt@no.findus.com*	Jan 20, 2011	Kontaktinformasjon
176.	*Anderson,Jennifer*	Jan 20, 2011	Re: Dietary Fiber
177.	*kai@nen.no*	Jan 19, 2011	Kartlegging av pressrester
178.	*guenther.laufenberg@bayer.com*	Jan 18, 2011	Re: use of waste from fruit and vegetable producti...
179.	*rune.bakke@hit.no*	Jan 14, 2011	Pressrester og avfall fra frukt og grønnsaker
180.	*Bjørge Westereng*	Jan 14, 2011	RE: Kontaktperson
181.	*Elisabeth Fjærvoll Olsen*	Jan 14, 2011	RE: Kontaktperson
182.	*Epleblomsten v/ Britt Sauar*	Jan 14, 2011	Re: SV: Fruktavfall og pressrester
183.	*Stavland Hermetikk AS*	Jan 14, 2011	Re: SV: Pressrester og avfall
184.	*Gunhild Akervold Dalen*	Jan 14, 2011	Re: Fw: Vs: Clean Label
185.	*elisabeth.fjaervoll.olsen@umb.no*	Jan 14, 2011	Kontaktperson
186.	*studieveileder-ikbm@umb.no*	Jan 14, 2011	Kontaktperson
187.	*Anderson,Jennifer*	Jan 14, 2011	Re: Dietary Fiber
188.	*aijn@aijn.org*	Jan 14, 2011	Waste from juice production
189.	*ifu@ifu-fruitjuice.com*	Jan 13, 2011	master thesis about waste from fruits and vegetabl...
190.	*info@ift.org*	Jan 13, 2011	Master thesis about waste from fruits and vegetabl...
191.	*mail@guentherlaufenberg.de*	Jan 13, 2011	use of waste from fruit and vegetable production
192.	*g.laufenberg@uni-bonn.de*	Jan 13, 2011	master thesis about waste from fruits and vegetabl...
193.	*jennifer.anderson@colostate.edu*	Jan 13, 2011	Dietary Fiber

194.	*stavland@stavland.no*	Jan 13, 2011	Pressrester og avfall
195.	*forbrukerservice@stabburet.no*	Jan 13, 2011	Re: Ad: Saksnummer. # WEB-615: Avfall og pressrest...
196.	*kontakt_oss*	Jan 13, 2011	Re: SV: Fruktavfall og pressrester
197.	*Inger Grøttum*	Jan 13, 2011	Re: Avfall
198.	*Astrid Lier Rømuld*	Jan 11, 2011	Re: Pressrester
199.	*post@epleblomsten.no*	Jan 11, 2011	Fruktavfall og pressrester
200.	*postmottak@hardangercider.no*	Jan 11, 2011	Fruktavfall og pressrester
201.	*hanne.linnert@bama.no*	Jan 11, 2011	Fruktavfall og pressrester
202.	*post@forbrukerraadet.no*	Jan 10, 2011	Clean Label (Mat)
203.	*postmottak@mattilsynet.no*	Jan 10, 2011	Clean Label
204.	*post.st@nofima.no*	Jan 10, 2011	Clean Label
205.	*ingrediens@nofima.no*	Jan 10, 2011	Clean Label
206.	*nofima@nofima.no*	Jan 10, 2011	Clean Label
207.	*mat@nofima.no*	Jan 10, 2011	Clean Label

Appendix C - Total waste globally with value calculation sorted by continents.xlsx

This appendix is too big to implement in this document, see the attached CD.

Appendix D - All waste per country by continents.xlsx

This appendix is too big to implement in this document, see the attached CD.

Appendix E - Answer from various actors

Norway	
Askim Frukt - og Bærpresseri Astrid Lier Rømuld Daglig leder/Manager	"Residues from production are delivered to farmers as animal feed for pigs."
Hardanger saft og Siderfabrikk AS Nils Lekve 5730 Ulvik	"Our waste usually goes to animal feed for sheep's. A reasonable way to handle the waste."
Hardangersaft (eid av findus) Terje Bleie Driftssjef Findus Norge AS Avd Hardanger	"Most of the residues from the apples go to animal feed. Approximately 150 tons. All waste of blackcurrant goes to a waste disposal site."
Epleblomsten AS Britt Sauar	"As of today we pay to get rid of the waste to a person who uses it for soil cultivation."
Stabburet Rygge Inger Grøttum Kvalitetsjef	"We don't have any waste from the production of tomato ketchup at Stabburet Rygge"
Stavland Hermetikk AS Anders J. Stavland Daglig leder	"We buy tomato purée from abroad and don't have any waste from production."
Telemark University College Prof. Rune Bakke	"We have only done some research on biogas production from apples."

Sweden	
Brämhults, Sverige (Webside) *http://www.bramhults.se/se/braemhults/vaart-miljoearbete*	"At Brämhults we are proud of our cooperation in order to extract bio-energy from our residues which also are reused as feed and soil fertilizer to farmers in Vastra Gøtalandsbygden."

Germany	
Ing. Andreas W. Dietz Dietz International	"Kelterei Possmann possmann.de - We did 20.000 tons apples per day (crushing, pressing) given free of charge to the German farmers."
Klaus Heitlinger Verband der deutschen Fruchtsaft-Industrie	"The German fruit juice industry produces about 800.000 t of fruits, mainly apples, a much smaller amount pears as well as sour cherry and red currant. We have approx. 200.000 t pomace, 75 % out of which pectin is made. There's only one company in Germany which produces it, Herbstreith & Fox. The rest of the pomaces go to biogas plants, animal and wildlife feeding." "For biogas it is given for free to the biogas producer if they pay the transportation (normally within max. 20 km distance from the juice factory). For animal feed (wildlife or stable) it's the same."

Cyprus	
Kikoula Cotsapas KEAN SOFT DRINKS LTD. Limassol, Cyprus www.kean.com.cy	"From the citrus fruit we extract the juice, we take the essential oil from the skin and we give the peels as is to the cattle growers to feed their animals." "There is no secondary processing in Cyprus to produce pectin, pellets or other from the peels."

Sør Amerika	
Larissa Popp CitrusBR - biggest Brazilian producers and exporters of citrus juices and derivatives Brazil	"All parts of the orange are used after the juice is extracted and many by-products are made. Citrus pulp pellets, which is used for animal feed." "98% of the orange juice plants in Brazil is CitrusBR associates and they there have no solid residues." "Production Brazil 2009: 18 340 240 tons of oranges."

USA	
Freshly Squeezed Ethanol Feedstock http://www.biomassmagazine.com/articles/1531/freshly-squeezed-ethanol-feedstock	"The Florida citrus industry produces 3.5 to 5 tons of citrus waste every year."
Ethanol feedstock from citrus peel waste http://findarticles.com/p/articles/mi_m3741/is_4_54/ai_n26835229/	"The current goal is to build a 10,000-gallon operation. Florida's citrus peel waste could yield up to 80 million gallons of ethanol per year."

Appendix F - Protein price calculation

This appendix is too big to implement in this document, see the attached CD.

		Raw material prices for animal feed (US $/tonne)												
Protein source animal feed		Dec 2010	Nov 2010	Oct 2010	Sept 2010	Aug 2010	Jul 2010	Jun 2010	May 2010	Apr 2010	Mar 2010	Feb 2010	Jan 2010	Ref.
Soy.pell, 48% protein, Brazil, cif Rott		443	443	424	411	398	366	348	353	346	339	382	409	Oil world
Rape meal, 34% protein,fob ex-mill Hmb		289	289	284	277	247	227	196	228	203	200	231	240	Oil World
Fishmeal, 64/65% protein, Bremen fca(h)		1520	1609	1710	1645	1629	1715	1747	1821	1874	1672	1627	1681	Oil World

Protein source animal feed	Weighted calculation of price (%)	Raw material prices for animal feed, US $/tonne												
		Dec 2010	Nov 2010	Oct 2010	Sept 2010	Aug 2010	Jul 2010	Jun 2010	May 2010	Apr 2010	Mar 2010	Feb 2010	Jan 2010	Reference
Soy.pell, 48% protein, Brazil, cif Rott	10	44,30	44,30	42,40	41,10	39,80	36,60	34,80	35,30	34,60	33,90	38,20	40,90	Oil world
Rape meal, 34% protein,fob ex-mill Hmb	2,5	7,23	7,23	7,10	6,93	6,18	5,68	4,90	5,70	5,08	5,00	5,78	6,00	Oil World
Fishmeal, 64/65% protein, Bremen fca(h)	2,5	38,00	40,23	42,75	41,13	40,73	42,88	43,68	45,53	46,85	41,80	40,68	42,03	Oil World
Total price protein, animal feed 2010	15	89,53	91,75	92,25	89,15	86,70	85,15	83,38	86,53	86,53	80,70	84,65	88,93	Oil World

Total protein price, animal feed, average 2010:	**87,10**	**$/kg**

Total protein price, animal feed, average 2010, a mix of 3 ingredients, ca. 45,5 % protein:	**581**	**$/ton**

Appendix G - Total waste from each raw material sorted by countries

This appendix is too big to implement in this document, see the attached CD.

Appendix H - Explanation of spreadsheets

To make the reading of the spreadsheets in excel a bit easier we have written explanations to each of them.

Chemical composition of raw materials.xlsx

The file contains the list of different raw materials' chemical content. All figures in the table are % (stated in the scientific reports as g/100g or %). The scientific reports the data are taken from are referred to in the column "Article" (or under the column "Link", if the file is a web based article). The excel file makes it possible to compare the potential raw materials against each other.

Total waste globally with value calculation sorted by continents.xlsx

This file shows the volume of waste from all kinds of commodities produced in parts of the world. The excel file contains a sheet for each continent which is ranked by the raw materials that have the highest waste volume in the given part of the world.

The sheet showing the data for the world focuses on the 30 most important raw materials based research on volume and chemical contents. The other sheets for the continents have been narrowed down to 20 raw materials because not all 30 raw materials can be found in big volumes in all continents. This is also been done in order to focus only on the most important raw materials per continent. The sheets also show value calculations based on cellulose, protein or pectin as price driver. This gives the value of the given volume of waste.

The *top three sources and countries* sheet shows the 3 countries with the biggest volumes of waste of the top 3 raw material volumes per continent. These volumes have also been calculated into value. The excel file makes it possible to see which raw materials that are available in big volumes and how much it will possibly cost to buy a certain volume of raw materials.

Total waste from each raw material sorted by countries.xlsx

This file shows the volume of waste from the production of the 30 selected raw materials in all countries. The excel file contains a sheet for each raw material and the numbers are ranked according to which country that has the highest volume of waste from the given raw material. The excel file gives an overview of which country in the world that has the most waste of the given raw material.

All waste per country by continents.xlsx

This spreadsheet shows a ranking of the biggest waste volumes per country in each continent. The excel file makes it possible to find which countries that have several big sources of waste and therefore could be a very potential location for the production.

Data on waste volumes are taken from the website of the Food and Agriculture Organization of the United Nations: http://faostat.fao.org/site/616/default.aspx.

Data on chemical composition are collected from several scientific reports, mostly found on: http://www.sciencedirect.com.

Protein price calculation.xlsx

To calculate the protein value of the raw materials we needed an estimate for the protein price per ton. Per-Ivar Heier at Borregaard recommended us to contact Knut Røflo at *Felleskjøpet's Fôrutvikling.* The spread sheet *Protein price calculation.xlsx* is showing how the calculation was executed.

The first table is an abstract from Oil World Price Survey, which is a confidential document at Felleskjøpet. The abstract shows the three main ingredients in animal feed and their price in US $/ton in 2010 (Knut Røflo, 2011). The second table shows how the ingredients are weighted in % and a calculation of price for each month.

By the further calculations in the spread sheet we found that the protein price is approximately 581 $/ton.

Reference list

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