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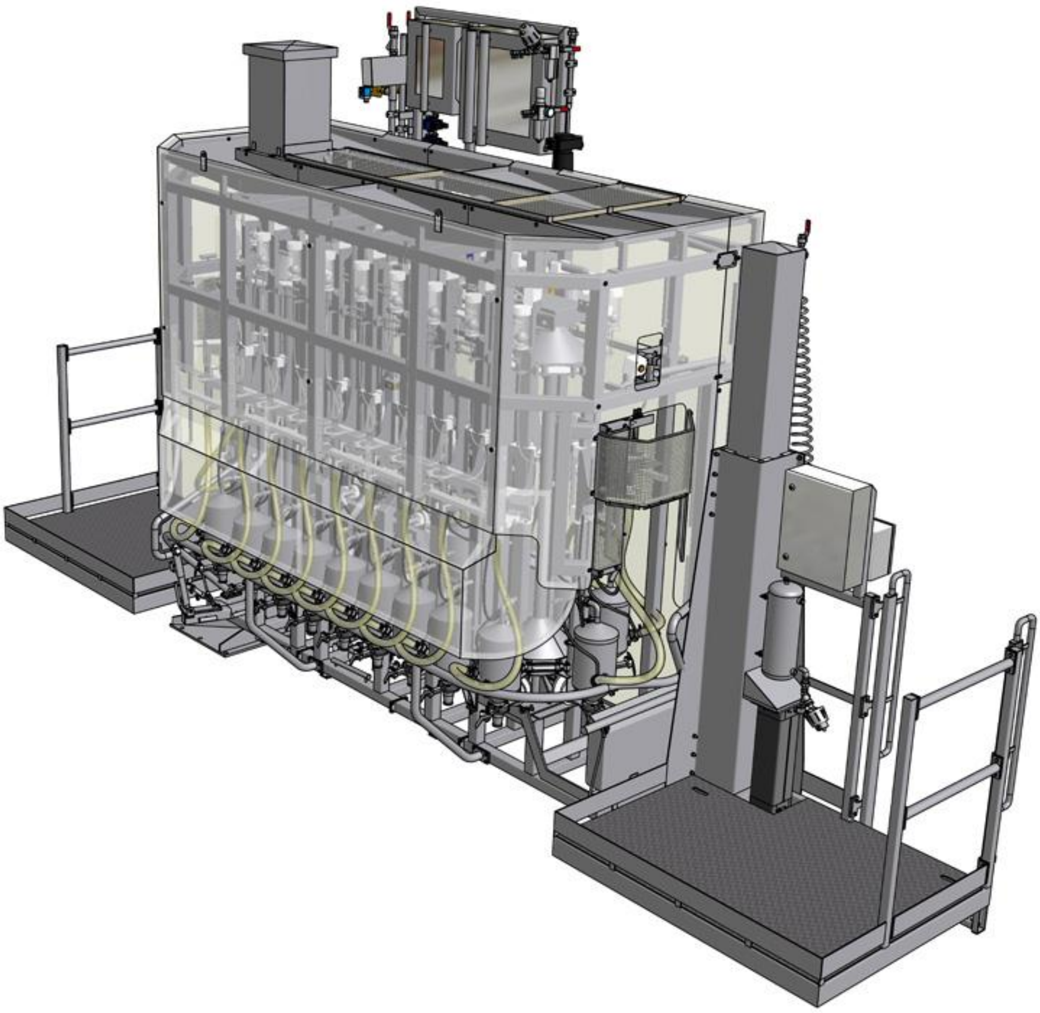
Opportunities for Porcine Blood Valorization for the ABC Slaughterhouse



MSc Thesis

Tanin Sinsathitchai
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OPPORTUNITIES FOR PORCINE BLOOD VALORIZATION FOR THE ABC SLAUGHTERHOUSE

Major Thesis

MST – 80436

Student: Tanin Sinsathitchai
Registration number: 860819764090
Program: MSc. Food Technology, Food Innovation and Management
Email: Tanin.sinsathitchai@wur.nl
S-tanin@hotmail.com

First Academic Advisor: Dr. Frances T.J.M. Fortuin: Food Valley NL
Department: Management Studies
Email: Frances.fortuin@foodvalley.nl

Second Academic Advisor: Prof. Dr. S.W.F. (Onno) Omta: Wageningen University
Department: Management Studies
Email: Onno.omta@wur.nl

External Advisor: Albert van den Dungen: Vleeshandel ABC XYZ B.V.
Department: Plant Manager Operations
Email: Albert.dungen@ABC-meat.com
Version: 4 November 2014
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Preface and acknowledgement

During my past eleven months, I have been working on my master thesis with an intention to finalize the Master program Food Technology, specialization Food Innovation and Management at the Wageningen University. This report is the product.

Combining scientific and management related a topic that must be covered in a thesis was not an easy work to begin with. However, a topic on valorization of by-products and waste streams from a pig slaughterhouse in the Netherlands caught my attention. Some initial research made me believe that there is not so many solutions are available for the company, but I was wrong. Because when I started to explore the company's inventory, observe real time situation, and study more literatures, I found numerous opportunities of valorization from the slaughterhouse. Hence, I decided it would be a challenging topic for my thesis, and undeniably, it was. During my early months, I struggled with plenty of valorization methods, but it has increased my knowledge on several types of valorization technologies expansively. I learnt many things during the empirical research phase, which was a very wonderful experience. I have intensely collected data from the ABC slaughterhouse and it has a great value for this research.

All the time, my supervisors have been of great help. First, I would like to thank Dr. Onno Omta and Dr. Frances Fortuin, for introducing a valuable thesis to me and always providing constructive feedback. The willingness to share their knowledge and experience allowed me to improve my academic proficiencies further and to apply it in practical case. Secondly, special thanks to Albert van den Dungen, who has supported me and provided essential information when I was gathering the data. Lastly, I would like to thank all the ABC employees that were willing to help in this research, as it resulted in a plan for better utilizing porcine blood from the ABC slaughterhouse in the Netherlands.

Executive summary

The ABC slaughterhouse is a large size pig slaughterhouse, which slaughters over one million pigs/year or around 5,000 pigs/day, located in XYZ, the Netherlands. With a rich history of operating in this sector for over four decades, the company is truly an expert at the pig slaughtering process. Due to the fact that the urban area of XYZ is expanding, the company is forced by the municipality to relocate to a rural region in the next fifteen years. Therefore, they plan to build a new pig slaughterhouse together with a research center, the Teeuwissen Group, which is specialize in pharmaceuticals, pet foods, human consumption productions, and ingredients, to valorize their products. This study is a part of their valorization plans for the new slaughterhouse.

Up to now, the porcine blood from the slaughterhouse has been underutilized, as the company needs to pay to dispose the major portion of the blood (destruction blood) through Rendac Company and the rest (blood fit for use in human products) is sold to Sonac Company without any value-added. This blood is safe for human consumption or can be processed into any foodstuff, taking EU legislation into account. Destruction blood is not fit for human consumption but it still can be processed into a variety of products such as fertilizer. The conventional bleeding method, using a knife that slits a pig's throat, is the reason for dividing blood into these two categories as blood might contaminate the environment; thus, the company must separate blood into two reservoirs to prevent cross-contamination.

The objective of this study is to answer to the following research question: *'What is the most suitable valorization method for porcine blood from the ABC pig slaughterhouse in the Netherlands in terms of technological feasibility, local and international economic potential, taking the recently changed EU regulations into account?'* To address this problem, the technological, the economic, and the legal aspects of the PESTEL framework were examined. The review of the scientific literature revealed that porcine blood is a valuable source of protein and it can be valorized into several products using different technologies. The technological aspect included getting up-to-date information on equipment and methods that can be used for blood valorization; the economic aspect included calculating costs and benefits of the proposed valorization methods, and the legal aspect addresses the question whether the valorized products comply with EU laws and regulations.

Desk research was conducted to develop a deeper understanding into which technologies can be used to valorize porcine blood, taking the economic potential and compliance with EU legislation into account. Scientific literature postulate that blood is sterile in healthy living animals so if the company could employ equipment that can hygienically drain blood, this would greatly reduce the amount of disposed blood. The Anitec hollow knife is a technology that can be used for this, because it can hygienically collect blood from swine at a maximum rate of 85% of the drainable blood. Machine, process, and blood obtained from this method comply with EU Regulations (EC) No 852/2004, (EC) No 853/2004, and (EC) No 854/2004. These three regulations control the hygiene of human foodstuff (i.e. hemoglobin powder and plasma powder) at all production stages. According to Regulation (EC) No 1069/2009, Regulation (EU) No 575/2011, and Commission Regulation (EU) No 68/2013, animal feed, particularly blood meal (whole blood powder), can be extracted from blood

obtained by the hollow knife. In addition, bioactive peptides and isolated proteins from red blood cells (RBC) and plasma can be produced. However, due to the technical difficulties of the too advanced technology and the specific expertise and research and development (R&D) requirements needed, these possibilities were not included in the cost calculation, because they are not feasible to the company at this moment; even though, these products can generate more income to the slaughterhouse than human foodstuff and animal feed.

Essential equipment that is needed for producing hemoglobin powder and plasma powder are the hollow knife, a centrifuge, a membrane filtration and/or an evaporator, and a spray dryer. If the company wants to produce animal feed instead of human foodstuff, they need to switch from the last two machines to a steam coagulator and a disc dryer. With these seven technologies, feasible products that can be sold are food grade porcine blood, hemoglobin powder, plasma powder, and blood meal. It is important to note that the selling price of blood products fit for humans is higher than that of animal feed.

The diagram of the proposed valorization methods (First stage) are shown in Figure 1. The modules in the first stage premise are intended to show an overview of blood valorization processes that can be produced with only implementing new valorization equipment, while the second stage and others are possibilities for the upcoming years, because an R&D team is in needed of researching on how to valorize blood. The blue rectangle boxes are substances that can be processed into products. The diamond shapes are examples of feasible blood valorization technologies. The white rectangle boxes are optional processes for blood valorization whereas the green shapes display possible valorized products that can be produced through the valorization processes.

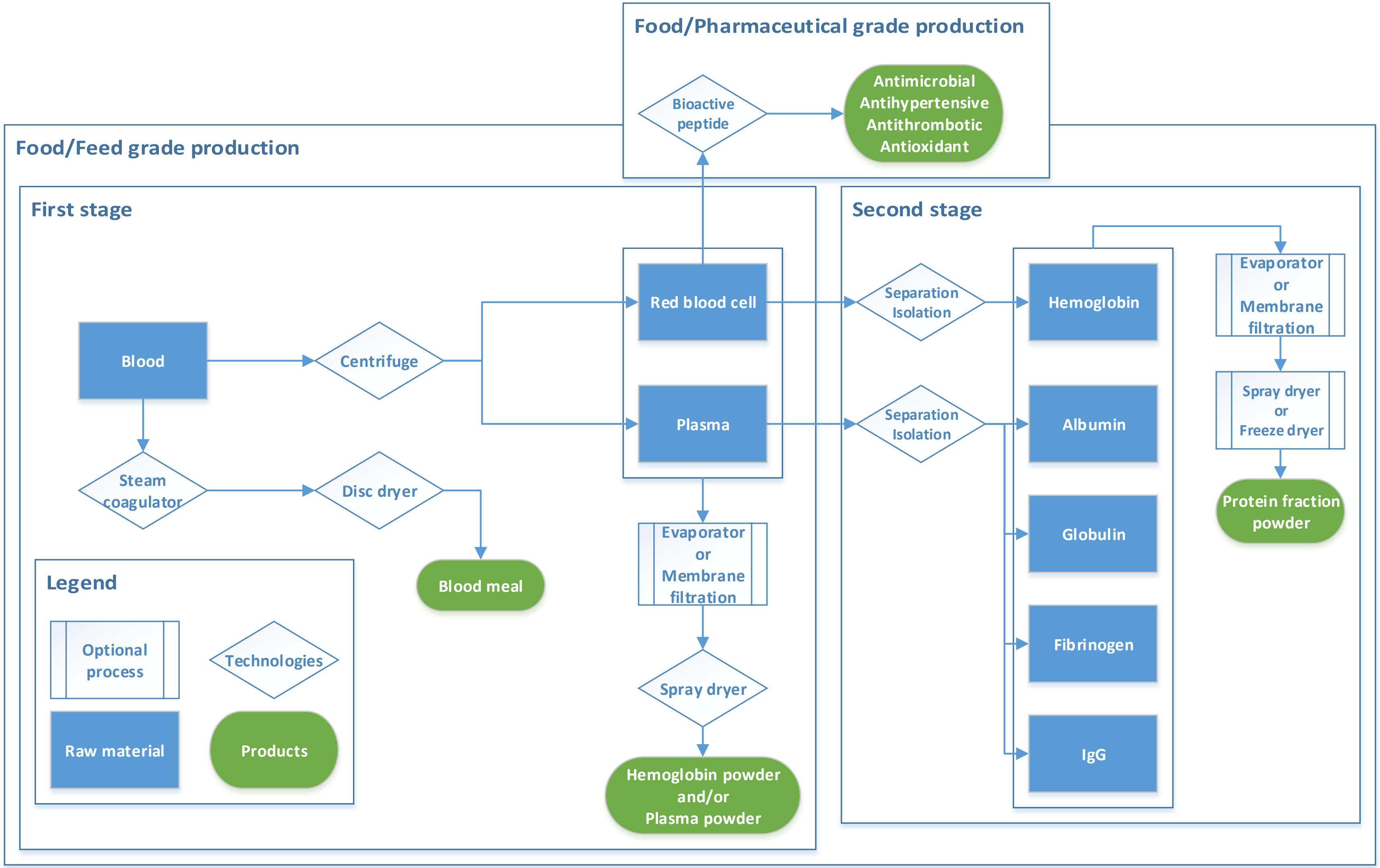

Figure 1: Blood valorization methods diagram

To evaluate the economic potential of the different valorization methods, costs, market size, and potential customers were analyzed. Costs of equipment were acquired from two suppliers: Butina (Anitec) Company and GEA Group while potential selling prices of products were retrieved from online sources and sales persons. A potential customers list was built using personal connections and companies that exhibited their products at the VIV (in Dutch: Vakbeurs Intensieve Veehouderij, in English: the trade fair for intensive animal farming) Europe exposition in May 2014. The human food additives market, the animal feed additives market, and the compound feed market were used, because there provide a large market share in the human and the animal feed segments. The compound annual growth rate (CAGR) of the compound feed market from 2007 to 2012 was almost 4%, whereas animal feed additives market starting from 2013 to 2020 is expected to be around 4%, and the market could reach 20 billion US dollars in 6 to 8 years. As for human food additives, CAGR during 2007 to 2012 was 2.1%, and the estimations of CAGR are around 3 to 6% from 2012 to 2018, and the forecasts for 2015 and 2018 are 33.9 billion US dollars and 36.1 billion US dollars, respectively.

Research was conducted to collect information on the blood production in the slaughterhouse. The empirical research focused on blood, and on the viscera (i.e. the heart, the stomach, the lung, and the intestines) and offal (i.e. the organs inside an animal, such as the brain, the heart, and the liver, eaten as food), as well. The pooled data of 71 days of blood collection in 2014 from the slaughterhouse revealed that the average figure of human consumption blood (the blood that is sold to Sonac) is 8,800 kg/day and for destruction blood, it is 11,400 kg/day, which is 43.65% and 56.35% of total blood, respectively. Since the amount of disposed blood was larger than the saleable blood, this explains why the company has been facing deficit from blood up to now. In addition, the selling price of human consumption blood is 40 €/ton while the disposed blood costs 40 €/ton to the company. It is clear that not only the disposed blood quantity is larger, but also the disposal costs are higher than the selling price of the blood fit for humans. Five schemes were formulated by combining the seven technologies together with the intention to search for the most profitable method. Table 1 shows the categorization of seven proposed technologies in five schemes using 'X' as a symbol of necessity. The five blood valorization schemes with the seven valorization technologies (in rectangle boxes with bold font and numbers) are displayed in Figure 2.

Table 1: Categorization of seven blood valorization technologies into five schemes

	I	II	III	IV	V
1. Hollow knife	X		X	X	X
2. Centrifuge			X	X	X
3. Membrane filtration			X		
4. Evaporator				X	X
5. Steam coagulator		X			X
6. Disc dryer		X			X
7. Spray dryer			X	X	X

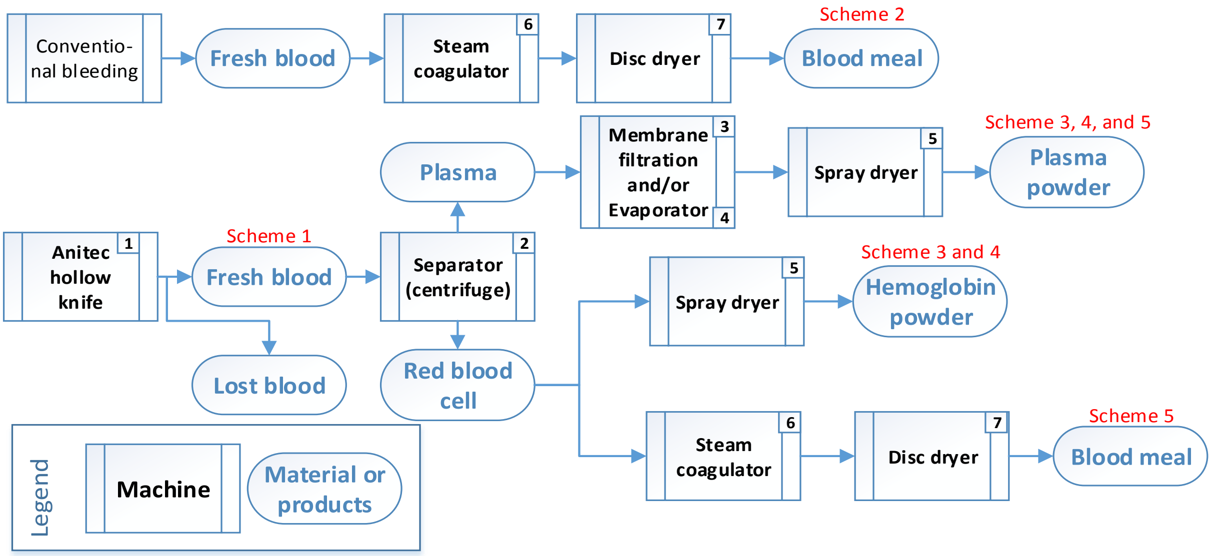

Figure 2: Comparison of processes and products from five blood valorization methods

These schemes are meant to be used for a new pig slaughterhouse, which will have an average slaughtered capacity of 6,931 pigs/day. The estimated total amount of porcine blood obtained from the new slaughterhouse is 33,982 kg/day. It can be further divided into human consumption (85%) and undrainable blood (15%). Thus, if the new slaughterhouse employs the hollow knife, they will obtain 27,312 kg per day blood.

The first scheme is the simplest valorization method consisting of the hollow knife and having human consumption blood as the product. The second scheme is the only method that can utilize whole blood without any loss, because this method uses the conventional bleeding technique, not the hollow knife, so that every drop of blood can be processed into blood meal. Requisite equipment for the second scheme is a steam coagulator and a disc dryer. Though, the third and the fourth schemes have the same products of hemoglobin powder and plasma powder, these are different in the concentration and drying stage, with the third scheme employing a membrane filtration (ultrafiltration) and two large spray dryers (capacity 1,000 kg) while the fourth scheme uses an evaporator and two small spray dryers (capacity 400 kg). The difference in spray dryer size is due to the difference between membrane filtration and the evaporator. An evaporator can reduce more water content from blood than membrane filtration can, so the company can install a smaller spray dryer in the fourth scheme. The downside of the evaporator lies in its price, which is twice as high as a membrane filtrator. The fifth scheme combines the notions of the second and the fourth schemes, so that plasma powder and blood meal can be produced. Machine requirements for the fifth scheme are the hollow knife, a centrifuge, an evaporator, a spray dryer, a steam coagulator, and a disc dryer.

To find which has the greatest benefits the return on investment (ROI) and break-even points (BEP) were calculated, the shorter the better. ROI formula and BEP formula that were used in the calculations are:

$$Break\ even\ point\ (BEP) = \frac{Fixed\ costs}{Selling\ price - (Variable\ costs + Semivariable\ costs)}$$

$$\text{Return on investment (ROI)} = \frac{\text{(Annual gains from investments} - \text{Annual investment costs)}}{\text{Annual investment costs}} \text{ x } 100$$

Costs and selling prices were obtained through suppliers and online databases. Due to the expertise of suppliers, the obtained selling prices from them are in exact number, while the others are in range. Sales persons from GEA Group suggested that regular maintenance cost is approximately 8% of the machine cost and the energy cost is around 225 €/ton. At least middle-level educated employees (in Dutch: MBO) are required for working in these schemes. The sales representative stated that their machines could last for 40 years, however since the machine might not last for 40 years because of changes in technology, the economic life cycle (ELC) of machines should be considered. According to Figure 1, if the slaughterhouse is successful in the first blood valorization stage, they are likely to expand their blood product lines. Consequently, the ELC of proposed valorization technologies might be shorten to approximately 15 years. At that time, two options are available for the slaughterhouse to choose. First, the company sells the current valorization equipment and starting a completely new production line. Second, the company runs the current production along with the future valorization. The advantage of the first option over the second is less investment, but the first option also generates less income when compared to the second option. The involved investment costs and selling prices are shown in Table 2.

Table 2: Summary of investment costs and selling price of five valorization schemes

	1	2	3	4	5
Expense					
Hollow knife machine 770,000 €/machine	1 machine		1 machine	1 machine	1 machine
Anticoagulant 56 – 1,400 €/day	Yes	Yes	Yes	Yes	Yes
Centrifuge 300,000 €/machine			1 machine	1 machine	1 machine
Membrane filtration (UF) 300,000 €/machine			1 machine		
Evaporator 650,000 €/machine				1 machine	1 machine
Steam coagulator 300,000 €/machine		1 machine			1 machine
Disc dryer 625,000 €/machine		1 machine			1 machine
Spray dryer (small) 900,000 €/machine			2 machines		1 machine
Spray dryer (large) 1,500,000				2 machines	

€/machine					
Employee 33 €/hour	1 person	2 persons	2 persons	2 persons	3 persons
Extra cleaning hour 33 €/hour	1 hour/day	1 hour/day	1 hour/day	1 hour/day	1 hour/day
Cleaning agents 5 €/day/machine	1 machine	2 machines	7 machines	7 machines	6 machines
Energy cost €/day	57.24	1,899	3,286	1,927	1,522
Maintenance cost 8% of equipment cost	€61,600	€74,000	€349,920	€333,920	€283,920
Income					
Fresh blood 40 €/ton	27.345 tons				
Blood meal 147 – 752 €/ton		5.989 tons			3.888 tons
Hemoglobin powder 1,000 €/ton			3.888 tons	3.888 tons	
Plasma powder 5,500 €/ton			1.313 tons	1.313 tons	1.313 tons
Summary					
Revenue (€/day)	899	909 – 4,494	11,200	11,200	7,888 – 9,999
Raw material cost (€/day)		899	899	899	899
Equipment cost (€)	770,000	925,000	4,374,000	3,524,000	3,549,000
Depreciation cost (€/year)	51,333	61,667	291,600	278,267	236,600
Maintenance (€/year)	61,600	74,000	349,920	281,920	283,920
Energy cost (€/day)	57.24	1,899	3,286	1,927	1,522
Labor cost (€/day)	238	414	414	414	613
Chemical cost (€/day)	61	66	81	81	86
BEP (years)	7.11	2.77[1]	2.31	1.55	1.61 – 2.66
ROI (%)	3.41	17.12[1]	53.10	107.33	50.11 – 96.13
Future BEP					
Income -10%	9.77 years	Deficit	2.91 years	1.77 years	3.31 years

[1] Might result in deficit if the selling price is lower than half of proposed prices

Income +10%	5.70 years	0.60 years[1]	1.91 years	1.31 years	1.45 years
Future ROI					
Income -10%	Deficit	Deficit	37.77%	86.01%	35.21%
Income +10%	13.87%	29.13%[1]	68.99%	127.55%	114.02%

The above table shows that the first scheme has the longest BEP of 7.11 calendar years. The second scheme is risky because it could have the shortest BEP of 2.77 years, but it could also result in net loss. The third scheme requires 2.31 years before it will reach BEP. The fourth scheme has the shortest BEP of 1.55 years. The fifth scheme takes 1.61 – 2.66 years for its BEP. When considering BEP as a main criterion, only the second scheme, the fourth scheme, and the fifth scheme are looking favorable, but if the slaughterhouse takes income of each scheme into account, the fourth scheme has the highest economic potential, because of the greatest expected revenues of 11,200 €/day. Using ROI as a criterion, both the fourth scheme and the fifth scheme look promising because of the highest ROI than the rest; however, the fifth scheme has a fluctuation in ROI, but the fourth scheme does not have. Therefore, the fourth scheme seems the most promising valorization method for the slaughterhouse.

Nonetheless, the proposed selling prices of valorized products are based on 2014, but the new slaughterhouse will be running in the next fifteen years; thus, it was assumed that the prices would fluctuate by 10%. The fluctuated prices are displayed in above table under the name of ‘Future BEP’ and ‘Future ROI’. As for the next 15 years, the scheme IV is still the most promising scheme, because it has the shortest BEP and the highest ROI compare to others. If the selling price decreases by 10%, the BEP and the ROI will be 1.77 years and 86.01%, respectively. The possible causes of this reduction in selling price might due to the spreading of the Swine Delta Coronavirus (SDCV), the shrinking of market, or the increasing number of new entrants (suppliers) leading to price cut. Conversely, if the price increases by 10%, both the BEP and the ROI will be 1.31 years and 127.55%, respectively. The economic potential of the scheme IV is getting higher due to the increasing of ROI and decreasing of BEP. The possible explanations of these circumstances are the growing in demand for valorized porcine blood or competitors move their products to new markets, or the current suppliers stop supplying to the market.

To suggest suitable stage 1 and 2 strategies for the company to valorize new blood products, a SWOT analysis along with Porter’s five forces were employed. The slaughterhouse has the strength of having abundant resources (blood) while their weaknesses are lack of R&D and blood valorization expertise. Opportunities of valorized products are growing market demands and collaboration with their business partners, whereas threats are swine disease and current occupants from blood products markets, such as, Sonac Company, Veos Company, and Proliant Company.

Additionally, the recent incident between Ukraine and Russia has a large impact on the ABC slaughterhouse because Russia, which is a potential customer, stopped importing goods from EU resulting in a massive amount of stocked pig meat. As of before the crisis, only uncooked meat products from the slaughterhouse were sold to Russia, but not including porcine blood; thus, this incident is indirectly related to the current business case of valorized blood products because of differences in customer groups (i.e. consumer, trade company, and food industry). Nonetheless, the company might short in the investment for the new slaughterhouse unless they can sell their stocked meat. The recommended solution for this situation is to export the stocked products to Greece, Poland, and United Kingdom, because they have steady growth rate in the volume of imported pig meat from the Netherlands since 2000. Moreover, the company could also export to Italy, Germany, and France, because they are also in the top six of pig meat importers of the Netherlands.

As for the economic aspect, CAGR of human foodstuff market and animal feed market during 2007 to 2012 are 2.1% and 4%, respectively, whereas they were forecasted to have CAGR around 3 – 4% in the next 6 years. These figures seem promising, and make it attractive for the slaughterhouse to invest in these valorized products because of both markets are continually growing. Since the slaughterhouse is the producer, they can sell at a lower price to compete in the markets. This means that the valorized blood products from the new slaughterhouse are expected to gain market share when they are launched.

The suggested stage 2 strategies for the company are hiring R&D staff to develop their own unique blood products and co-operating in developing new products with other firms, for example, AAA Group. To hire R&D staff to work at the company, a well-equipped laboratory is requisite; nevertheless, this will require a large amount of investment to build a high quality lab. The estimated costs of building a new lab can be from €500,000 to €1,000,000 or more. Apart from hiring R&D staff, the company can co-operate with a university or a research center, which will cost the slaughterhouse around 2,000 €/month/person until products are developed.

Contents

List of figures

List of tables

1. Introduction

From the accrued number of the world population, it is obviously seen that more resource is going to be sacrificed for humanity. Food problems are always on the top list of discussion topics that human face for a lengthy time, for example, food safety, malnourished food, food security, and the latest one is food waste (WHO 2013). Furthermore, the population of human is considerably raising in numbers which are going to increase from 7 billion in 2010 to more than 9 billion in 2050 (FAO 2006, FAO 2009, UN 2013). Because the increasing of population, this means that approximately 30% more of resources are going to be used in the near future.

The economic value of food waste on a global scale based-on producer prices from 2009, the total amount of food waste in 2007 was approximately 750 billion US dollars. The major contributors of food waste can categorize into four groups, which are vegetables (23% of the total cost), meat (21%), fruits (19%), and cereal (18%) (FAO 2013b). However, the number of meat waste is accounted for only four%, but the contribution to total economic is around 21% because of its high price per unit. Hence, this low volume, yet high in cost food waste are gained attention from several companies and organizations.

Nowadays, the food companies deliberately strive for producing products in a more sustainable way. Food Valley NL (FVN) is one of the leading innovation clusters in the agri-food business at a global scale. In recent times, FVN has started an innovation program, namely KiA (In Dutch: Koplopers in Ambitie) program, which is delicately designed to help the food companies to overcome the existing and upcoming challenges. The first subject of the KiA program is commercialization and utilization of by-products and food waste from food production sector.

Although, there are many research and studies about by-products and food waste; besides, valorization technologies have been invented to serve the purpose of reducing by-products and food waste, but practical application in the food business is not much seen. Thus, the purpose of this project is to gain insight into the potential value of by-products and waste streams (i.e. porcine blood) from the meat industry, particularly pig slaughterhouses.

In order to help food companies to gain insight in the potential of porcine blood, a field research based on the participated slaughterhouse was conducted to collect the necessary data. Not only the technological feasibility is of concern in this research, but also the economic potential, and related law and regulation are considered. Linking the three pillars of technology, economic, and regulation, along with the porcine blood data, the suitable valorization method is suggested at the end of this research.

1.1 Research Objective

The aim of this research is to valorize porcine blood that was generated from the ABC slaughterhouse, but not to search for methods to prevent generating of BWS, which is the best way to reduce food waste.

At the largest scale of food production, the world, the total meat production is at 296 million tonnes in year 2010, and the major contribution is pig meat (FAO 2013a). The amount of pig meat is 109 million tonnes, which is almost half of the total meat production (FAO 2013a). As for the case of pigs slaughtering, wastewater was produced from various processes are hazardous to humans (Jian and Zhang 1999). Jayathilakan, Sultana et al. (2012) postulated the number of viscera and by-products of pigs roughly at 50% of the live weight. While Gminder and Reyniers (2004) found that the human consumed only 68% of a chicken, 62% of a pig, 54% of a bovine animal, and 52% of a sheep or goat. Noticeably, amount of BWS from pigs are the largest proportion amongst other livestock; thus, blood as a part of BWS can bring significant revenue to the meat industry.

The recent study of Oakdene Hollins and WRAP (2010) revealed more detailed number that 16% of raw material in the food and drink industry was throwaway. Another study in UK revealed that out of 6.5 million tonnes of total grocery waste, 4.9 million tonnes or approximate 75% of food waste was from the manufacturing sector (WRAP 2013). Another recent study estimated at £23 billion the savings from low or no-cost resource efficiency measures companies could make in the UK (EC 2011c). Since UK and the Netherlands situate in Europe, it can assume that they share the similar figures of food waste.

This research was planned to conduct at a pig slaughterhouse in the Netherlands, because it considered being one of the places generating largest amount of BWS. At the same time, the ABC slaughterhouse from XYZ wanted to co-operate with FVN to valorize their BWS. The slaughterhouse planned to build a new abattoir in next fifteen years with completely new equipment and has an estimated slaughtering capacity of 6,931 pigs per day or 720 pigs per hour. Not only new capability equipment is of concern, but also economic and legal aspects are considered as well.

To suggest an appropriate valorization technology to the slaughterhouse, the waste information, such as, quality, quantity, and fluctuation of porcine blood are required for analyses and evaluations for the feasible technology. The purpose of this measurement is to provide a quick and simple assessment of BWS valorization as a practical situation. Besides the suitability of the technology, the economic potential, and law and regulation are of concern to technology selection as well.

By combining the aforementioned information along with previous literature study, a suggestion of valorization technology based on technological feasibility, economic potential, and laws and regulations deem to be an excellent solution for meat companies to realize the prospective of porcine blood valorization.

Focusing on the significance of porcine blood valorization, and taking the diverse crucial information into account, the objective of this research is to **"develop a set of valorization technologies for porcine blood based on technological feasibility, economic potential, and recently changed EU regulations for the ABC slaughterhouse"** This research aims to provide suitable solutions for the ABC slaughterhouse, and recommend the feasible options to successfully valorize porcine blood.

1.2 Theoretical framework

This section integrates the theoretical concepts from 2.2.2, 2.2.4, 2.2.6, and 2.4 into the theoretical framework. The purpose of the theoretical framework is to find a list of suitable valorization technologies for the ABC slaughterhouse. Information and data obtained from the empirical research phase was used as input in the framework. The PESTEL framework is integrated in the framework to assess the influential factors and impacts from the environments. Then, a SWOT analysis and Porter's five forces framework utilized results from the PESTEL framework to find suitable strategies for the firm.

In Figure 3, the theoretical framework, resulting from theoretical concepts, is used as a structure to generate a recommendation of suitable valorization methods. Each component is described in the following paragraphs.

1.2.1 PESTEL framework

The PESTEL framework describes six influential factors: political, economic, social, technological, environmental, and legal. (HIA 2011, Johnson, Scholes et al. 2012, Oxford Learning Lab 2012). These factors influence and affect every industry and company. However, this research focuses on only three factors: economic, technological, and legal, so that whether those three other factors influence the selection of suitable valorization technologies is not investigated. An assumption has been made that legal is the first influential factor, and is followed by risks and benefits (economic) assessment among proposed technologies. A set of feasible technology will be used for analysis with a SWOT analysis as a next step.

1.2.2 Porter's five forces framework

The Porter's five forces framework describes five situations that are likely to happen when the company move their products to compete in a new market or a new segment (Porter 1979, Porter 1996, Porter 2008, Johnson, Scholes et al. 2012). To fully utilize this framework, another analytical tool is needed to assess which situation the company might encounter in the forthcoming. Threat of new entrants, threat of suppliers, threat of buyers, threat of substitution, and rivalry amongst existing competitors are the five situations that are used as a structure to analyze the possible outcomes from the valorized porcine blood products.

1.2.3 SWOT analysis

A SWOT analysis reveals possible strategies for the company by inputting information from internal factors derived from the business (strengths and weakness) and external factors that influence them (opportunities and threats) (Weihrich 2382, Houben, Lenie et al. 1999, Nishadha 2012). When combined data from the company and results from the PESTEL framework together a TOWS matrix can be created. The interaction among four factors in the TOWS matrix will create four strategies. The researcher will select the most suitable method for valorization to the ABC slaughterhouse and recommend this to the firm.

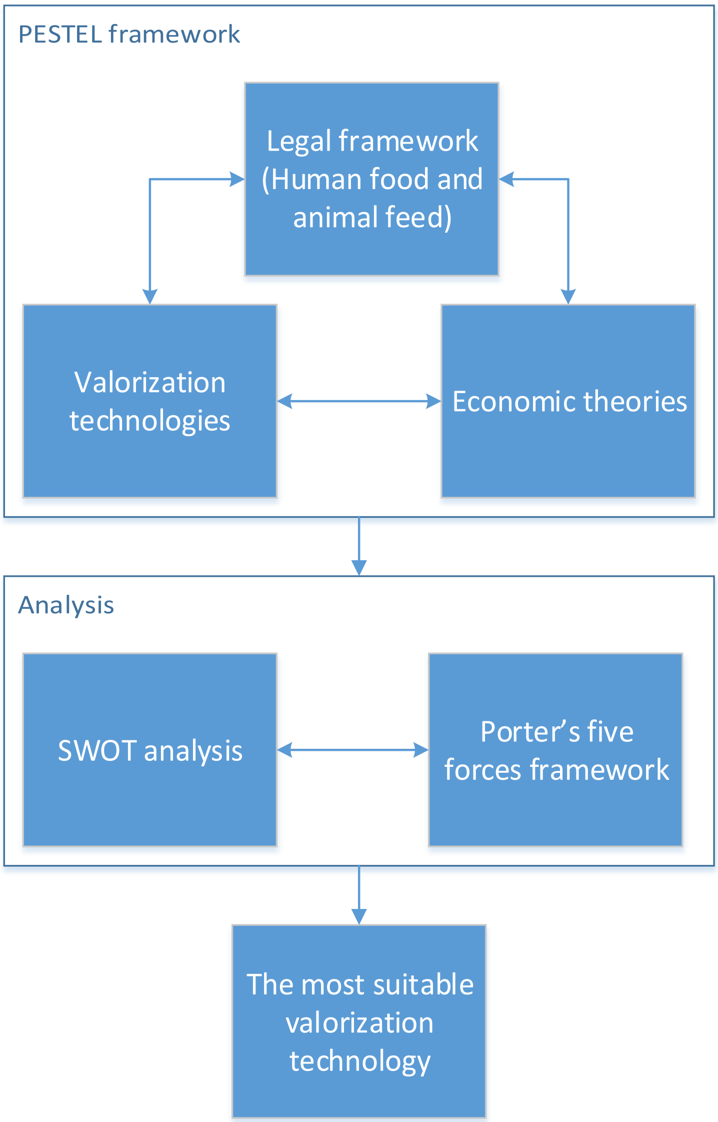

Figure 3: Theoretical framework

From the above figure, three elements in the PESTEL framework interact with others to find the greatest benefits valorization technologies for the company by using empirical data as input. The results gained from the framework were analyzed by a SWOT analysis and Porter's five forces framework to assess compatibility of proposed technologies and the ABC slaughterhouse that will result in the possible various strategies for the firm.

1.3 Research Question

This section deals with formulating the research questions. The research framework presented in the previous chapter will result in research questions. In this chapter, the main research question and a number of sub questions are created. When gathered all of the answered sub-questions, the main research question will be answered as well.

Central research question is "What is the most suitable valorization method for porcine blood from the ABC slaughterhouse in terms of technological feasibility, local and international economic potential, and the recently changed EU regulations?"

Sub-questions:

1. What criteria are of use to analyze the technological feasibility of valorization methods of porcine blood from the ABC slaughterhouse?
   a) What are attributes of porcine blood from the slaughterhouse?
   b) What are the suitable valorization technologies for the porcine blood from the slaughterhouse?
   c) Who are the suitable suppliers according to the chosen valorization method?
2. What criteria are of use to analyze the economic potential of valorization methods of porcine blood from the ABC slaughterhouse?
   a) What is the suitable business strategy that could be applied to analyze the economic potential?
   b) Who are the potential customers for valorized porcine blood?
   c) What is the current market size of valorized porcine blood?
   d) Among the currently used valorization methods and the proposed methods, which methods provide the greatest economic benefit to the ABC slaughterhouse?
3. What EU laws and regulations are effective against both of porcine blood as raw material and valorized porcine blood?
   a) What EU laws and regulations are effective against porcine blood as raw material?
   b) What EU laws and regulations are effective against valorized porcine blood?

The answered sub research questions should contribute to answering the central research question. After the first, second, and third sub research questions have been answered, a set of feasible valorization methods should be developed for the participated slaughterhouse. The first sub research question would point out the feasible valorization technologies up to this day; the current situation problems of porcine blood from the ABC slaughterhouse and the possible options of transforming it into human foodstuffs, animal feed, or other value-added products. The second sub research question is about economic potential of the feasible valorization method. The third sub research question considers laws and regulations that have effect on porcine blood and valorized products.

The first and the second sub research questions will take law and regulation from the third sub research question into account for legitimate solutions. The answers from the third sub research question will act as a fundamental requirement in searching for the available solutions. From the outcomes of the first, the second, and the third sub research questions, the essential information will be gathered; thus, the assessment of feasible valorization technologies is going to execute in the central research question. As a final point, the results from the central research question would unveil the most suitable method for the slaughterhouse and future stakeholders dealing with the similar process of porcine blood from the ABC slaughterhouses.

2. Literature study

The results of the literature study are discussed in this chapter. The chapter discusses the attributes of porcine blood, new and feasible valorization technologies, the economic potential of valorized porcine blood, and presents a SWOT analysis. The chapter starts with a discussion of the literature concerning porcine blood. It addresses its properties and attributes so that the researcher can select a suitable valorization technology. Subsequently, the technological, economic, and legal aspects are considered under a PESTEL framework in section 2.2. This framework is the pillar of this chapter because it helps to contribute in answering most of the sub research questions (see section 1.2). Additionally, Porter's five forces framework assists in selecting the suitable strategy presented in a SWOT analysis, which is introduced in subsection 2.2.6, with the intention to improve the results from the PESTEL framework. Lastly, the theoretical framework is created in section 1.2 by linking the previous sections together.

2.1 Porcine blood

Blood is a manifestly ubiquitous by-product in slaughterhouses. The amount of blood that is possible to recover from the live weight of the pig is around 3 – 4% (Wismer-Pedersen 2388, Liu 2002, ANITEC n.d.). Normally, blood is sterile in a live and healthy animal (Liu 2002, Dàvila Ribot 2007) so a slaughterhouse can make use of the blood for human consumption if they hygienically collect it. Apart from water, the major component in porcine blood is protein; approximately 18% of whole blood (Anon 2007, ANITEC n.d.). Hemoglobin and plasma are major elements of whole blood where around 40% is hemoglobin and almost 60% is plasma (Wismer-Pedersen 2388, Toldra, Elias et al. 2004, Anon 2007, Bah, Bekhit et al. 2013, ANITEC n.d.). Hemoglobin consists of heme (pigment) and globin (protein) while the major components of plasma contain thrombin (protein), fibrinogen (protein), and albumin (protein). Table 3 displays blood composition with details.

Table 3: Components of blood and its fractions —plasma and red blood cells— by percentage of weight from Ockerman and Hansen (2388) according to (Dàvila Ribot 2007)

Constituent	Blood	Plasma (60%)	Red blood cells (40%)
Water	80	90.8	60.8
Salts	0.9	0.8	1.1
Fat	0.2	0.1	0.4
Protein	17	7.9	35.1
Albumin	2.8	4.2	-
Globulin	2.2	3.3	-
Fibrinogen	0.3	0.4	-
Hemoglobin	10	-	30
Other	1.1	0.4	2.6

Porcine blood has vast potential owing to its protein components. Therefore, the following will discuss the function of proteins, properties, and applications of each processed protein in multiple industries.

The general physicochemical characteristic of blood is its ability to clot, but this can be prevented by adding an anticoagulant such as (mono-, di-, or tri-) sodium citrate, heparin, or EthyleneDiamineTetraAcetic acid (EDTA). Sodium citrate is predominantly used in many research (Chinprahast, Jantawat et al. 1995, Liu 2002, Toldra, Davila et al. 2008, Liu, Kong et al. 2010, Hurtado, Dagà et al. 2011, Álvarez, García et al. 2012, Ofori and Hsieh 2012, Bah, Bekhit et al. 2013, Chandrasekaran 2013, Pares, Toldra et al. 2014, ANITEC n.d., CSIRO n.d., Kitsavat and Khunajakr n.d.). Blood clotting is a technique that can separate red blood cells from serum; serum is plasma without fibrinogen, by not using anticoagulant when draining blood from animals. Clotted blood can be further processed and serve as animal feed or fertilizer. It is low value and it devalues the plasma because fibrinogen is already merged with the red blood cells (RBC), which make plasma loses another protein component. Normally, companies separate hemoglobin and plasma so that they can easily process them and sell at a higher price.

Hemoglobin is the main protein component of RBC; having heme and globin as sub-components. Hemoglobin consists of four globin molecules and four heme molecules. Each heme contains one iron element atom, so heme can be mixed with food as a supplement in iron deficient patients. In addition, the meat industry also uses heme as red pigment to add color to their food products such as sausage (Ofori and Hsieh 2012, ANITEC n.d.). While heme has various usages in food, globin does not have any particular application aside from protein fortification in human foodstuff or animal feed. With some effort, several companies have put products derived from hemoglobin on the market labeled as a sustainable protein source (Ofori and Hsieh 2012).

As stated above, plasma is the major constituent of porcine blood and it consists of a variety of proteins. Plasma proteins have been widely used in sausages, luncheon meat, cooked ham, and similar food products due to its water binding and fat emulsification capabilities (Toldra, Elias et al. 2004, Tseng, Tsai et al. 2006, Anon 2007, Hurtado, Dagà et al. 2011, Ofori and Hsieh 2012, Chandrasekaran 2013, Pares, Toldra et al. 2014, ANITEC n.d., Kitsavat and Khunajakr n.d.). Several companies such as Sonac BV in the Netherlands have isolated or mixed proteins from RBC and plasma, and these are commercially available. Examples of commercialized products are illustrated in Table 4 and applications of blood in various industries are displayed in Table 5.

Table 4: Examples of blood-derived protein ingredients used as food additives and dietary supplements (Ofori and Hsieh 2012, Ofori and Hsieh 2014)

Product	Company	Country	Description
Aprofer 1000	APC Europe	Spain	Heme iron polypeptide
Prietin	Lican Functional Protein Source	Chile	Spray dried porcine whole blood
Myored	Lican Functional Protein Source	Chile	Natural red colorant from the red pigments of blood
Proferrin ES	Colorado Biolabs	USA	Heme iron polypeptide
Proferrin Forte	Colorado Biolabs	USA	Heme iron peptide plus folic acid
AproRed	Proliant	USA	Stabilized hemoglobin

ImmunoLin	Proliant	USA	Serum concentrate
NutraGammax	Proliant	USA	Serum protein isolate
Fibrimex	Sonac BV	Netherlands	Thrombin and fibrinogen protein isolate
Plasma Powder FG	Sonac BV	Netherlands	Plasma with increased fibrinogen concentration
Proglobulin	Sonac BV	Netherlands	Porcine plasma for weaned piglets
Harimix (C, P, or P+)	Sonac BV	Netherlands	Stabilized hemoglobin
Hemoglobin	Sonac BV	Netherlands	Frozen or Powder hemoglobin
PP	Sonac BV	Netherlands	Frozen or Powder plasma
Vepro globin	Veos NV	Belgium	Globin as emulsifier in meat product
Plasma	Veos NV	Belgium	Liquid, powder, frozen, or flaked plasma

Table 5: Utilization of blood in different sectors (Dàvila Ribot 2007)

Sector	Utilization
Food industry	Emulsifying, stabilizer, gelling, thickening, foaming, clarifying, coloring, enricher or fortifying agent
Animal feed	Supplement, vitamin stabilizer, diary substitute or enricher
Fertilizers	Seed coating, pH stabilizer, mineral enricher
Laboratory	Culture media, active coal, catalase, peptones, globulins, albumin
Medical	Agglutination tests, immunoglobulins, fractionation techniques, clotting factors, fibrinogen, fibrin, serotonin, plasminogen
Pharmaceutics	Cosmetics
Industry	Adhesive, insecticide coadjutant, cellular concrete, fire extinguisher, resin, leather, fabric ceramics and plastic additive

From the literature studies, the researcher found that blood is a versatile protein source because it can be used in many industry sectors. Aside from blood utilization (Table 5), recent research also reports that components from porcine blood were found as an ingredient in cigarette filters (Meindertsma, Rosmalen et al. 2007, Mackenzie and Chapman 2011). However, the application of blood protein needs to comply with EU laws and regulations – discussed in subsection 2.2.6. Therefore, each type of protein has their own unique properties; thus, the company can earn money by extracting, isolating, and selling specific proteins to other firms. Protein separation techniques and valorization technologies will be discussed in subsection 2.2.4 and economic theories will be discussed in subsection 2.2.2.

2.2 PESTEL framework

This section will focus on literature about strategic management that helps in answering the research question by applying a PESTEL framework. A PESTEL framework is widely used for getting a grip on influential factors and analyzes the impacts that might impact on the company (Oxford Learning Lab 2012). To better understand the complexity of this issue, which is in the nature of the business world, the business environment layers are introduced (Figure 4).

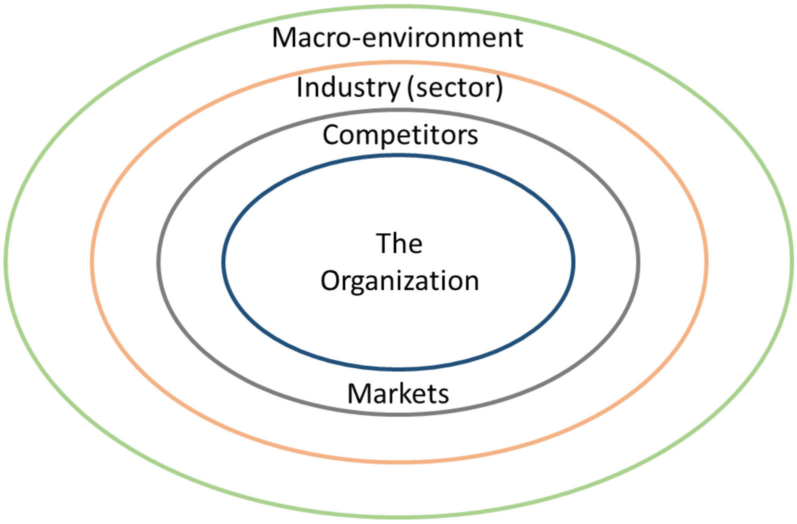

Figure 4: Layers of the business environment (adapted from (Johnson, Scholes et al. 2012))

In the highest level layer is the macro-environment, which can be explained by the PESTEL framework. A PESTEL framework categorizes the environmental influences into six prime types: political, economic, social, technological, environment, and legal (Johnson, Scholes et al. 2012). PESTEL is an extended version of the original PEST framework, the addition of 'E' and 'L' components are used to improve the scope of influential factors (HIA 2011, Johnson, Scholes et al. 2012, Nishadha 2012, Oxford Learning Lab 2012, Jurevicius 2013). In general, **P**olitics refers to the role of governments; **E**conomics refers to macro-economic influences such as growth of national economic, GDP, and business cycles; **S**ocial includes changing cultures and demographics; **T**echnological influences refer to new technology and innovations; **E**nvironment is specified in particularly for 'green' concepts, and lastly **L**egal takes any legislative constraint that may involve the company into consideration (Johnson, Scholes et al. 2012, Nishadha 2012, Oxford Learning Lab 2012, Jurevicius 2013). These components are always linked, which may simultaneously develop changes in other elements (Johnson, Scholes et al. 2012, Nishadha 2012, Oxford Learning Lab 2012, Jurevicius 2013).

A PESTEL framework aids users in analyzing a situation with broad data to identify the key drivers that affect organizations. The PESTEL framework covers most of the influential factors that have an impact on organizations, but the key drivers for changes vary from business to business (HIA 2011, Johnson, Scholes et al. 2012). In this study, economic, technological, and legal factors are likely to have a great effect on the ABC slaughterhouse. Therefore, the three main factors will be thoroughly studied in the subsequent sub sections. The economic factors are assessed in sub section 2.2.2, technological influences are studied in sub section 2.2.4, and the legal aspects will be analyzed in sub section 2.2.6.

The general practice of utilizing a PESTEL framework is by inputting the most likely influential factors in the analysis template to catch an overview of the situation (HIA 2011, Johnson, Scholes et al. 2012, Nishadha 2012). The more influential the factors listed in the analysis template the more precise the outcome will be.

After gathering the issues that are likely to affect the company, the next step is a process of analysis. It is necessary to prioritize the most influential factors and rank them so that management can focus on these (HIA 2011). Furthermore, the analysis results may reveal the threats and opportunities that can emerge, so that a firm adapts a strategy to meet the changes (Nishadha 2012).

Examples of issues that might affect the company are growth rates, labor costs, raw material fluctuations, stage of the business cycle, market size, and potential customers. From the list, there are answers for sub research questions underlying the influential factors. Therefore, not only pointing out the influential economic factors will reveal threats and opportunities to an organization, but the prominent causes will also help in answering the sub research questions.

2.2.1 **P**olitical

The first letter in the mnemonic of PESTEL, politics, has an undeniably powerful influence on a firm when relevant policy is considered. The Netherlands is a member of the European Union (EU); thus policies coming from the EU have an effect at state level (Government of the Netherlands n.d.). However, the impact of political factors depends on the level of interference from government or EU. An example of political factors that might affect the ABC slaughterhouse is the agreement between the Netherlands and China about the official announcement of trotter exportation (Pig Progress 2012). It remains unclear whether slaughterhouses can export their pig's feet to China due to the related legal and regulative issues. Nevertheless, the effects of political factors are excluded from this research due to the difficulty to anticipate upcoming policies that might have an unclear impact in the analysis. Thus, the influential factors from the political angle are not gathered and used in further analysis.

2.2.2 **E**conomic

This subsection aims to help in answering sub research question 2:

What criteria are of use to analyze the economic potential of valorization methods of porcine blood from the ABC slaughterhouse?

1. What is a suitable business strategy that could be applied to analyze the economic potential of porcine blood?
2. Who are the potential customers for valorized porcine blood?
3. What is the current market size of valorized porcine blood?
4. Among the currently used valorization methods and the proposed methods, which methods provide the greatest economic benefits to the ABC slaughterhouse?

As one of the mnemonics of the PESTEL framework, economic is an unquestionably powerful factor to any firm when they want to invest in a new business. Influential factors that contribute in answering the sub research questions can be found in the following paragraphs.

There are numerous factors have impacts on organizations, but only the selected titles will be studied due to the limits of time. The influences were selected based on criteria that are directly related to the valorized products, and the processes should be able to determine the success or failure of these products. The selected factors are potential customers for valorized products in sub subsection 2.2.2.1, market size of valorized products in sub subsection 2.2.2.2, and calculation of the total production cost in sub subsection 2.2.2.3.

2.2.2.1 Potential customers

A potential customer is an individual or company that is capable of becoming a purchaser from the firm and most likely to buy (Burst Creative 2009). As the economic aspect from the framework is also linked with other components in the PESTEL framework, potential customers were also determined by the attribute of valorized products. For that reason, the researcher selected human foodstuff and animal feed sectors as potentially important groups because food and feed markets have grown continuously in the last decade (FAO 2006, FAO 2009, FEFAC 2012, FAO 2013a). Two major groups of customers are from the food and feed sectors; some companies are firmly entrenched in both sectors such as Nutreco N.V., the Netherlands, and Charoen Pokphand group, Thailand. Customers with great buying power can drive the growth of the company, and vice versa. However, there is a specific requirement from the ABC slaughterhouse that they would like to offer valorized products that are not intended for end-users or consumers. Therefore, the possible potential customers in the current situation, which is a business-to-business model (B2B), are companies and organizations in the target sector. Nowadays, transportation and supply chains are well developed, thus customers are not limited to only neighboring countries, but also foreign customers from other continents are put on the list for consideration as well.

2.2.2.2 Market size

Market size is the number of individuals in a certain market who are potential buyers and/or sellers of a product or service (Anon n.d.). To estimate the market size of valorized porcine blood, it is important to identify the market segment or target market first. However, the target market is determined by the type of valorized products (i.e. food additive, feed additive, or animal feed). Then again, the types of finished goods are controlled by appropriate laws and regulations, which can be categorized into two major types: human foodstuff and animal feed. In this research, apart from the medicinal segment, the target market will be human foodstuff and animal feed, because products sold in these markets can generate high added-value, with less investment than the medicinal market.

More than 3,000 food additives are available worldwide (Pandey and Upadhyay 2012). The key players in food additives are Ajinomoto, Givaudan, Archer Daniels Midland (ADM), BASF, AVEBE, and Danisco (DuPont) (IFT 2010, Report Buyer 2013, Transparency Market Research 2014). The recent report found that Europe dominated the use of food additives with over 32% of global consumption in 2011 (Transparency Market Research 2014). Due to the confidentiality of data sources, this report did not include any specific statistics from each segment in the food additives market. However, the growth rate and forecast of data are accessible from several sources. The value of the global food additives market in 2011 was 28.2 billion US dollars and the forecasts for 2015 and 2018 are 33.9 billion US dollars and

36.1 billion US dollars, respectively (IFT 2010, Transparency Market Research 2014). The estimations of compound annual growth rate (CAGR) are around 2.1% from 2007 to 2012 and 3 to 6% from 2012 to 2018 (Hennessy 2013, Report Buyer 2013, Transparency Market Research 2014). According to this information, there is more room for growth in this sector in the next few years; and, eventually, these keys suppliers can turn into customers for the finished products from the ABC slaughterhouse.

In 2013, animal feed additives is seen as the largest segment, accounting for almost 45% of the overall animal health sector (Grand View Research 2014). Key players in the animal feed additives segment are: Addcon Group, Adisseo France S.A.S, Kemin Industries, BIOMIN Holding, Elanco Animal Health, DSM, Novus International, Nutreco, Novozymes, Evonik, Archer Daniels Midland (ADM), BASF, Cargill, and CHR Hansen (Clark 2014, Grand View Research 2014, Marketsandmarkets.com 2014). Estimation of market size during 2012 to 2013 is around 14 to 16 billion US dollars, and it could reach 20 billion US dollars in 6 to 8 years (Clark 2014, Grand View Research 2014, Marketsandmarkets.com 2014). The CAGR starting from 2013 to 2020 is expected to be around 4% (Grand View Research 2014, Marketsandmarkets.com 2014) that is similar to the past of compound animal feed CAGR of around 4% (Wattpad n.d.). This segment is still growing because of the increase in global meat consumption, of which the poultry market is estimated to be the largest for feed additives and swine is the second largest in the segment (Clark 2014, Marketsandmarkets.com 2014). Within the animal feed additive industry, the amino acid group has the largest market share accounting for 30 – 40% of the market (IHS 2013, Grand View Research 2014).

To summarize, both food additives and feed additive market values, as representatives from human foodstuff and animal feed sectors, are expected to grow at a rate of 3 – 4% from 2013 to 2020. The estimated market sizes in the next six years are around 36 and 20 billion US dollars for food additives and feed additives, respectively. Consequently, both sectors seem highly promising for investment.

2.2.2.3 Cost accounting

This segment describes the general terms that are used in cost accounting, which will be applied for calculation of the total production cost. Without knowing the cost, the company cannot estimate the potential for profits of the project. Cost accounting comprises of three elements: manufacturing cost, non-manufacturing cost, and cost behavior. Cost accounting will be used to evaluate the economic potential of presented valorization technologies in sub subsection 2.2.4.1, which will be put forward and recommended to the ABC slaughterhouse as the main objective of this research.

Cost accounting is a useful tool used mainly by a financial analyst or management team to determine essential costs for running a business. There are four main components for cost accounting in the project: labor, materials, machinery, and overheads (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). In addition, each of the main components has its sub-components, for example, the machinery cost may contain three components: set-up, hourly usage, and maintenance costs. The amount of components or sub-components depends on the nature of businesses, for instance, the costs such as machine maintenance, production set up, production inspection, and material handling are unique to the manufacturers (Vanderbeck 2009).

The principle of cost accounting has been developed to enable manufacturers to measure the resources that must be spent in order to obtain a product or complete the activity (Vanderbeck 2009, Callahan, Stetz et al. 2011). All types of business units require cost accounting information to investigate and analyze their activities so that managements can control the 'in progress' operations and plan for the next one. The major element that can be obtained from cost accounting is expenditure. Cost is typically expressed in monetary terms, for example, price of purchased raw materials, amount of consumption of transportation gas, or labor salaries, which can be represented in monetary value (Callahan, Stetz et al. 2011).

Generally, cost falls into either management accounting or cost accounting fields, and has four prime purposes (Callahan, Stetz et al. 2011).

1. It is used to calculate revenue from the organization's projects, operations, or activities.
2. It is used for information gathering before making a decision throughout the organization.
3. For planning forthcoming activities or operations, cost data is fundamentally needed.
4. It is used for determination of occurring variance when comparing actual results with estimation cost.

In the aforementioned paragraph, the nature and form of cost can be varied across countries or organizations. The examples of types of organizations are manufacturer, marketing, retail, or service. As a pig slaughterhouse is classified as a manufacturer, this research will focus solely on costs that have effects on the valorized blood and processes.

2.2.2.3.1 Manufacturing cost

The costs of most manufacturing companies can be divided into two major categories: manufacturing cost and non-manufacturing cost. The manufacturing cost can be sub-divided into three: direct materials, direct labor, and manufacturing overheads, whereas non-manufacturing cost consists of selling and administrative cost (Garrison, Noreen et al. 2011). An explanation for the two main groups can be found in the following paragraphs.

Direct materials
Raw materials are resources that undergo processing into a final product – while the final product from one company can be raw material for other firms (Vanderbeck 2009, Garrison, Noreen et al. 2011). In the case of a pig slaughterhouse, the raw material is live pigs and the final products of the slaughterhouse are hams, blood, heart, carcass, etc. Though ham is a final product from the slaughterhouse, other companies can process it further into their final product such as cured ham, Serrano ham, pies, etc.

Raw materials used in the final product may comprise of both direct and indirect materials. Direct material is one that is transformed or becomes an integral part of the finished product, and the cost of raw material can be traced conveniently in the finished product (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). Conversely, an indirect material is difficult to trace the cost of raw material, and thus it will be included as part of manufacturing overheads, which will be described later in this section. Examples of direct and indirect costs in the ABC slaughterhouse are the purchase price of pigs, and transportation cost of delivering pigs to the slaughterhouse.

Direct labor

Similar to direct material cost, direct labor consists of labor costs that are easily tracked to individual units of product or stock keeping units (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). A stock keep unit is a particular identifier to inform the amount of items in the inventory or system, for example, blood powder is impossible to measure in a number of particles; thus it is more convenient to pack in 20 kg plastic bags – the 20 kg bag is a stock keeping unit. On the contrary, indirect labor is akin to an indirect material; the indirect labor cost is inconvenient to trace as part of the finished product. Operatives who cut the carcass into specific parts are direct labor. While janitors or security guards who work at the slaughterhouse, whilst necessary for the company, but it would be a cumbersome task to calculate precisely the cost of these employees into each final product unit.

Manufacturing overheads

Manufacturing overheads are the third and the last component of manufacturing cost. As a last element, the manufacturing cost covers every cost that is not include direct labor and direct materials, such as, maintenance cost, repair cost, tax, etc (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). However, the only cost involved in operating the factory will be included as manufacturing overheads while the other costs; for example, marketing, insurance, and consultancy are non-manufacturing costs.

Summary of manufacturing cost

Only the costs of direct materials, direct labor, and manufacturing overheads are included in manufacturing cost. Nonetheless, marketing cost, the administrative fee, and non-factory expenditures are not included as manufacturing cost, but count as a non-manufacturing cost, which will be explained in the following paragraphs. However, some of the costs will fall into both categories of manufacturing and non-manufacturing cost; in this circumstance, the ambiguous costs are needed to be allocated to both in suitable proportions. The examples of ambiguous costs that fall into both categories are property tax, insurance, and depreciation (Vanderbeck 2009).

In addition, there are two more terms involved in the manufacturing cost – prime cost and conversion cost. Prime cost is the sum of direct materials and direct labor costs. Conversion cost is the sum of direct labor and manufacturing overheads costs. When direct material is transformed into the final product, direct labor and manufacturing overheads cost are necessary to convert the direct material into finished goods; thus they can be combined and called conversion cost (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). The relationships of manufacturing cost are illustrated in Figure 5.

2.2.2.3.2 Non-manufacturing cost

Non-manufacturing costs are usually divided into two categories: selling costs and administrative costs (Garrison, Noreen et al. 2011). Non-manufacturing cost is also known as selling, general, and administrative (SG&A) cost; but, sometimes, it is shortened to selling and administrative (S&A) costs.

Selling cost
Selling costs comprise of expenditures used for securing customer's orders, and to deliver the finished products to the customer, for example, shipping cost of finished products, payment for rented warehouses for finished goods, or sales commission (Garrison, Noreen et al. 2011).

Administrative cost
Generally, this cost is not involved with selling and manufacturing costs, it is always associated with general management of the organization rather than aforementioned costs (Garrison, Noreen et al. 2011). Corporate social responsibility (CSR), executive salaries, and general accounting are examples of administrative costs that involve the general management of the whole organization.

Summary of non-manufacturing cost
When combining both manufacturing and non-manufacturing cost together, the total amount of costs is revealed in the company's system and the management team can make the best possible decision for the current operation, or the forthcoming production effectively based on the information from cost accounting. Without non-manufacturing cost, it is impossible to make an accurate estimation for the total cost of the business unit; thus, the management team must always consider the accounting cost when starting to enter a new market or industry.
The summary of manufacturing and nonmanufacturing cost is illustrated in Figure 5.

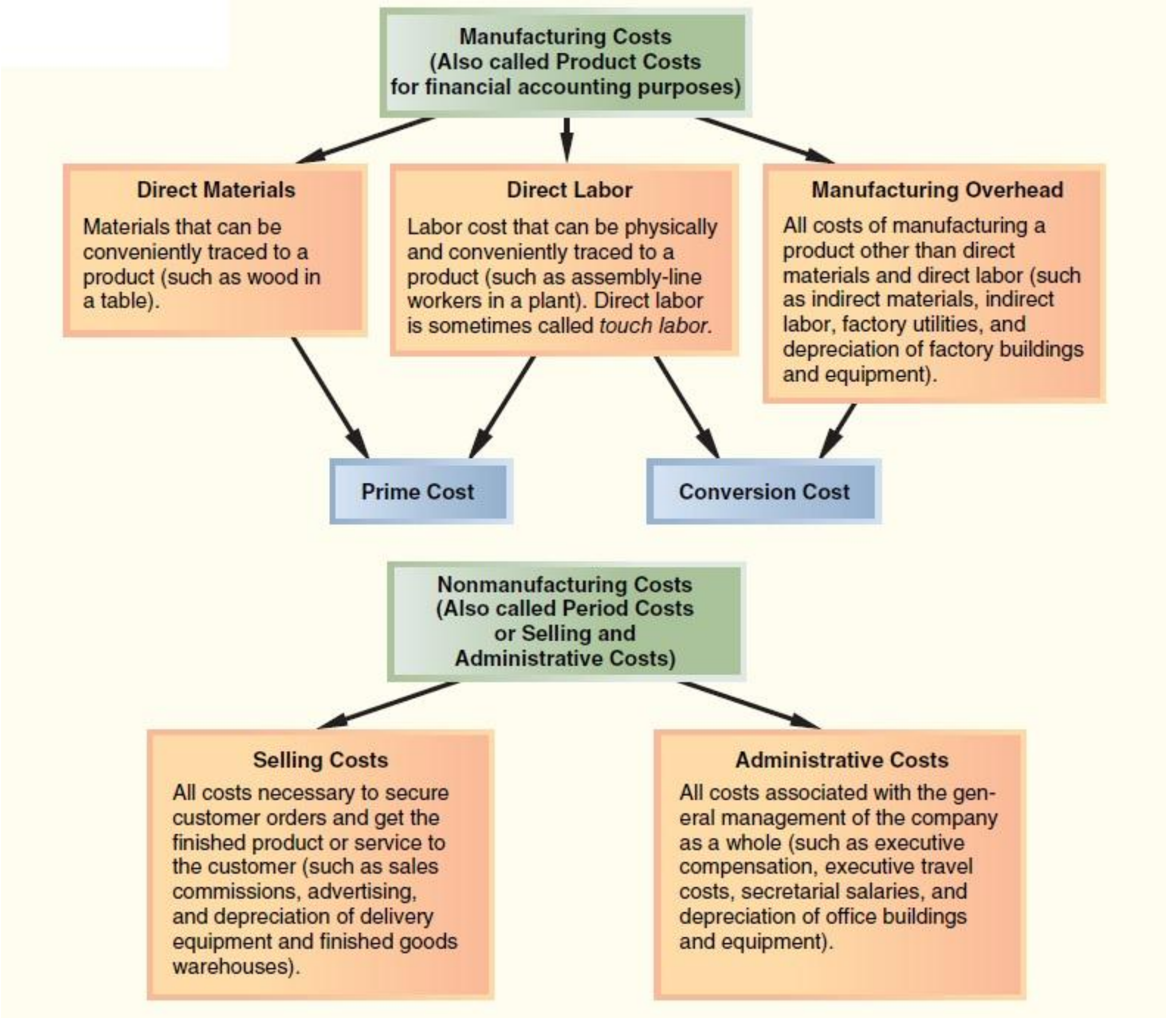

Figure 5: Summary of manufacturing and nonmanufacturing cost terms (adapted from (Garrison, Noreen et al. 2011))

2.2.2.3.3 Cost behavior

Certain activities influence cost in different ways; thus cost behavior refers to how a cost reacts to a particular change in the level of activity (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). Once the activity level changes, specific cost may rise and fall, or remain constant, depending on the nature of change and type of cost. Cost behavior is valuable information in predicting or planning future activities or production estimates.

Cost behavior is usually categorized into three major types these are fixed, variable, and semi-variable costs. There are slight differences for each cost behavior in particular situations. With a certain situation, there might be two extra behaviors; sunk cost and opportunity cost.

Fixed cost
Fixed costs always remain constant despite changes in the level of business activities (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). For instance, the cost of property tax or rental cost of a warehouse remains the same regardless of the quantity of finished products that may be stored in the facility. The behavior of fixed cost (not per unit cost)

displayed in graph format can be found in Figure 6. Although the fixed cost does not rise or fall in response to the level of activity, it still incurs the finished unit cost. If the production yield of cured ham dropped from 1,000 pieces to 500 pieces per day, the fixed cost will directly affect the unit cost of cured ham, resulting in a two-fold increase of fixed cost in the unit cost. In other words, this means that the finished product of 1,000 pieces has a fixed cost of €0.05 per piece while 500 pieces of finished product have a fixed cost of €0.10 per piece.

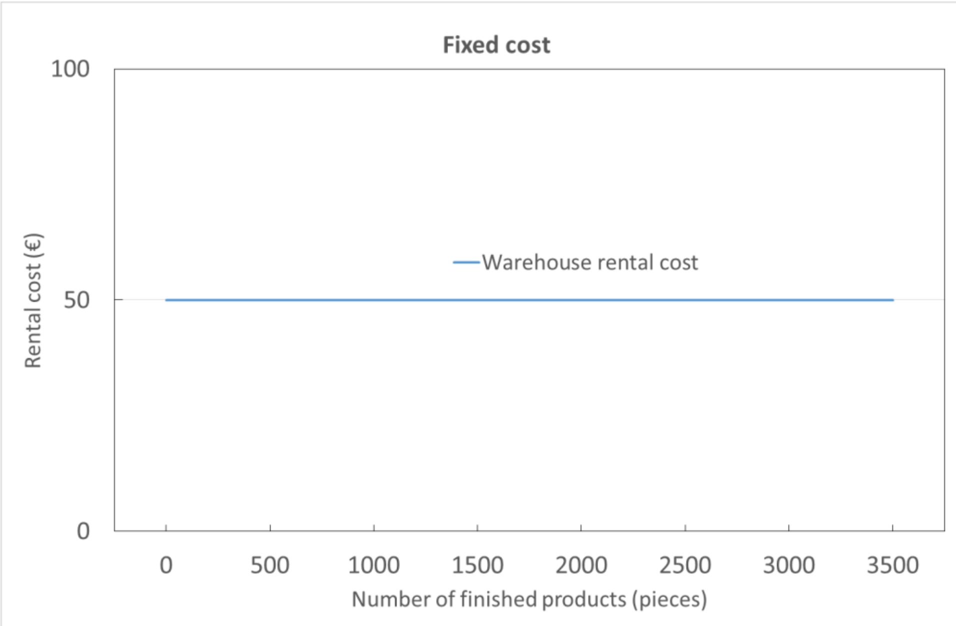

Figure 6: The relationship of rental cost and number of finished products (fixed cost)

Variable cost

In contrast to a fixed cost, variable cost is a change in the direct relationship to the proportion of changes in the level of activity (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). The cost often increases by the same proportion of finished goods produced. Intrinsically, the variable cost is a fixed cost per unit produced or activity used, but for the cost to be varied, it needs to fluctuate with respect to something. For example, the more cured ham is produced, the more cost of ingredients is increased for each cured ham. The concept of variable cost is displayed in graph format in Figure 7. Unlike fixed cost, which is always constant and can lower the fixed cost per unit in mass production, the variable cost per unit often remains the same regardless the quantity of finished products made.

There is another type of variable cost that can be obtained through large quantities of purchasing called step variable cost (Callahan, Stetz et al. 2011). When a buyer wants to purchase the same material in bulk, the seller can lower the unit price for the purchaser. For example, a retailer wants to buy cured ham from the meat packer. A single batch of 1,000 pieces of cured ham costs €9,000 or €9 apiece. Ten batches of 10,000 pieces of cured ham might be €70,000 or €7 apiece.

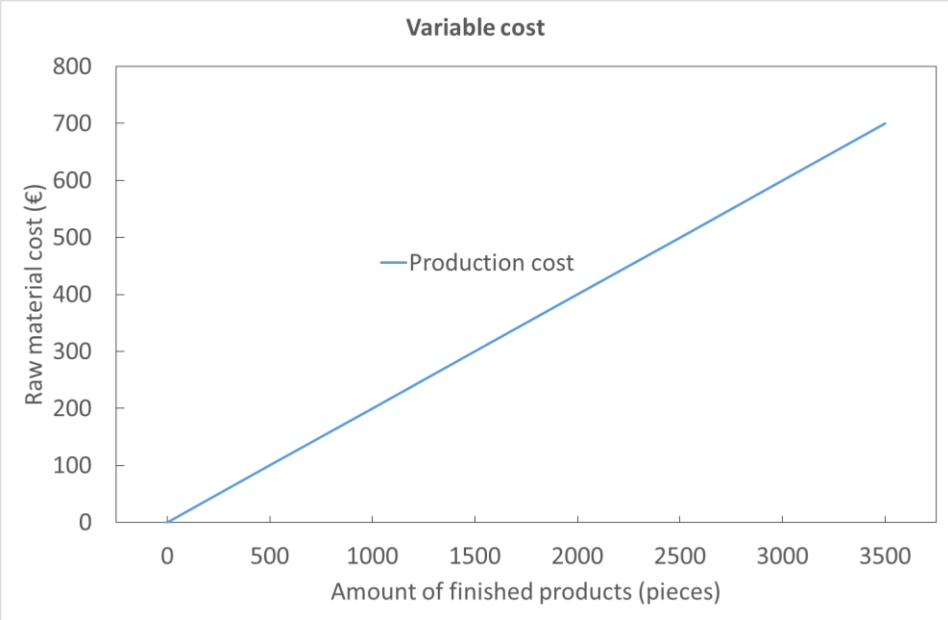

Figure 7: The relationship of raw material cost and amount of finished products (variable cost)

Semi-variable cost

As its name implies, semi-variable cost contains both fixed cost and variable cost elements – sometimes this is called a mixed cost (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). If a company is going to start producing a new line, the firm may need to buy a new machine for the process. The cost of new machinery is €10,000; however, if we break down the cost of the equipment, for example, it might consist of setup cost, maintenance cost, and machine hour cost. We can say that set up cost and maintenance cost are fixed while the machine hour cost is a variable. To elaborate, semi-variable cost calculation into a simple equation, it would look like this:

$$Y = a + bX$$

In this equation,

Y = the total of semi-variable cost
a = the total of fixed cost
b = the variable of cost per unit or level of activity
X = the amount of unit or level of activity

We can transform the above equation into a graphic as in *Figure 8*. At the intercept point of both vertical and horizontal lines, there is no machine hour cost, but the setup cost exists. At the peak of production load, the setup remains the same – €100, whereas the variable cost rises to €700.

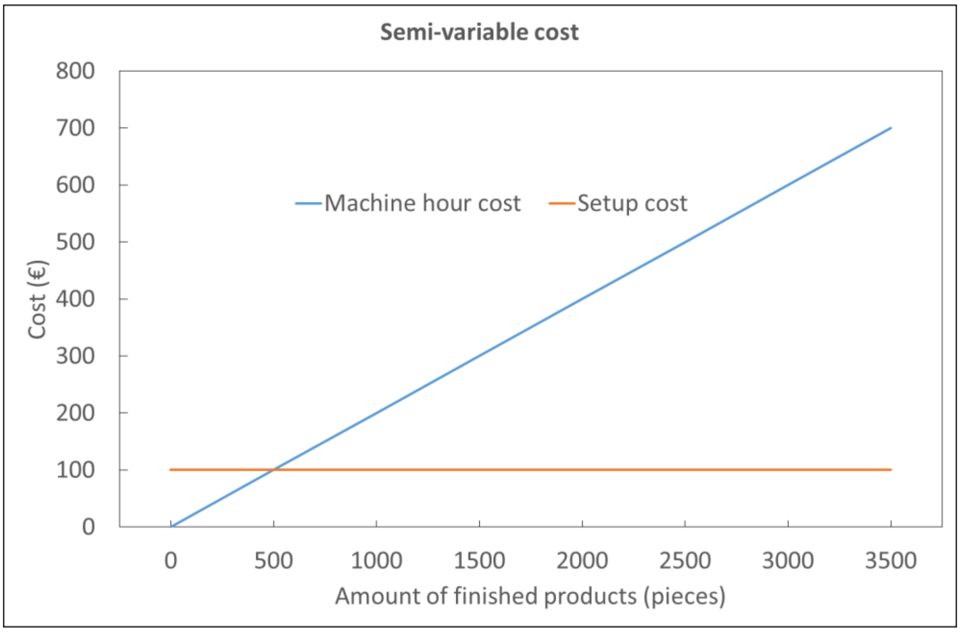

Figure 8: The relationship of machine hour cost and setup cost with the amount of finished products (semi-variable cost)

Sunk cost

Sunk cost is one that had already been incurred, and cannot be changed by any decision whether now or in the future (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). Sometimes, managers decide to overspend the money in the project. For instance, the estimation of the project is supposed to cost €5,000 but at the time, €8,000 was already spent or sunk into this project. The company must make a decision whether to continue or not. Even if the company decided to continue, there is no guarantee that this will be successful. On the other hand, it may be greatly more successful than any of the past projects. This awkward circumstance often happens in projects that are not going well.

Opportunity cost

Opportunity cost is one that needs to be paid when making a decision to select or pursue one benefit over another (Callahan, Stetz et al. 2011, Garrison, Noreen et al. 2011). Even though opportunity cost is normally important when making a decision, opportunity cost will not be displayed in the cost accounting. Practically every decision involves an opportunity cost. Some examples of opportunity cost might be:

- A slaughterhouse is choosing between investing in a biogas production plant or a blood powder production. The biogas production plant can generate less income than blood powder; however, the biogas production plant is also less risky as a long-term investment.
- A manager is considering the possibility of starting a new production of pet food in his plant, or outsourcing the ABC Company to produce pet food for the firm. Obviously, the first option provides more profit to the firm, but is also riskier than the second option.

Summary of cost behavior

Cost behavior consists of three major types and two minor types. The three major types, which often shown themselves in most accounting statements are fixed cost, variable cost, and semi-variable cost. The two minor types, which are not often clearly seen, are sunk cost and opportunity cost. Though they are called minor costs, they are also very important when someone needs to make a decision for the company. Virtually every cost in practical projects can be categorized into both major and minor types; in most cases, combining these two will result in the total cost of the project.

2.2.3 **S**ocial

The social aspect of the PESTEL framework represents the culture of the society that an organization or company operates within. This may come from changes including lifestyle, buying trends, media, ethics, beliefs, demographics, living conditions, social mobility, level of education, and attitude (Eiamsri 2011, HIA 2011, Johnson, Scholes et al. 2012, Nishadha 2012, Oxford Learning Lab 2012, Jurevicius 2013). Due to the fact that this research has limited amount of time and the scope of influential factors from the social aspect of PESTEL is immense and not directly related to the project, this factor will be excluded from the study. Excluding social factors from the research means that the researcher can focus on the remaining influential factors.

2.2.4 **T**echnological

By identifying the technological factor from the PESTEL framework, it can contribute in answering sub research question 1: ‘What are the suitable valorization technologies for porcine blood from the ABC slaughterhouse?’ and ‘Who are the suitable suppliers according to the chosen method?’

Technological aspects can be innovations, changes in technology, manufacturing, licensing and patents, and accessibility to the new technology (Eiamsri 2011, HIA 2011, Johnson, Scholes et al. 2012, Nishadha 2012, Oxford Learning Lab 2012, Jurevicius 2013). Within a limited timeframe, only the blood valorization technologies and suitable supplier companies will be discussed in this section.

2.2.4.1 Valorization technology

In this subsection, the multiple valorization technologies will be presented and discussed. The aim of this part is to provide a list of feasible technologies for the company to choose from based on their interest and attributes of raw materials. From the point of view of the researcher and company representative, porcine blood currently does not generate much income for the firm, which it can be valorized to add value to the finished products. In addition, the company has a condition that the valorized porcine blood products are going to be sold to other firms, not to consumers. Thereby, the presented valorized technologies in this subsection will have specific properties to use porcine blood as raw material, and the processed porcine blood can be sold to other industries. Since there are many valorization methods that can be used to produce various products (Chinprahast, Jantawat et al. 1995, Rosentrater and Flores 1997, Liu 2002, Anon 2007, Toldra, Davila et al. 2008, Liu, Kong et al. 2010, Hurtado, Dagà et al. 2011, Mackenzie and Chapman 2011, Álvarez, García et al. 2012, Ofori and Hsieh 2012, Bah, Bekhit et al. 2013, Chandrasekaran 2013, Ofori and Hsieh 2014, ANITEC n.d., CSIRO n.d., Kitsavat and Khunajakr n.d.), and numerous type of industries that can be served from processed porcine blood; hence the simplest valorization technologies generate high income in human foodstuff or the animal feed industry.

In order to select suitable valorization technologies, a value pyramid is presented in Figure 9. The value pyramid shows a set of products that can be obtained from valorization. Pharmaceutical products and high-end chemicals are the apex of the value pyramid while energy products, such as, fuel and heat, are at the bottom of the pyramid. The more value being added to the product the more advanced production technology and a larger investment are required. In addition, the company is not interested in energy investment; thus, this research will focus on products in the top three levels of the value pyramid.

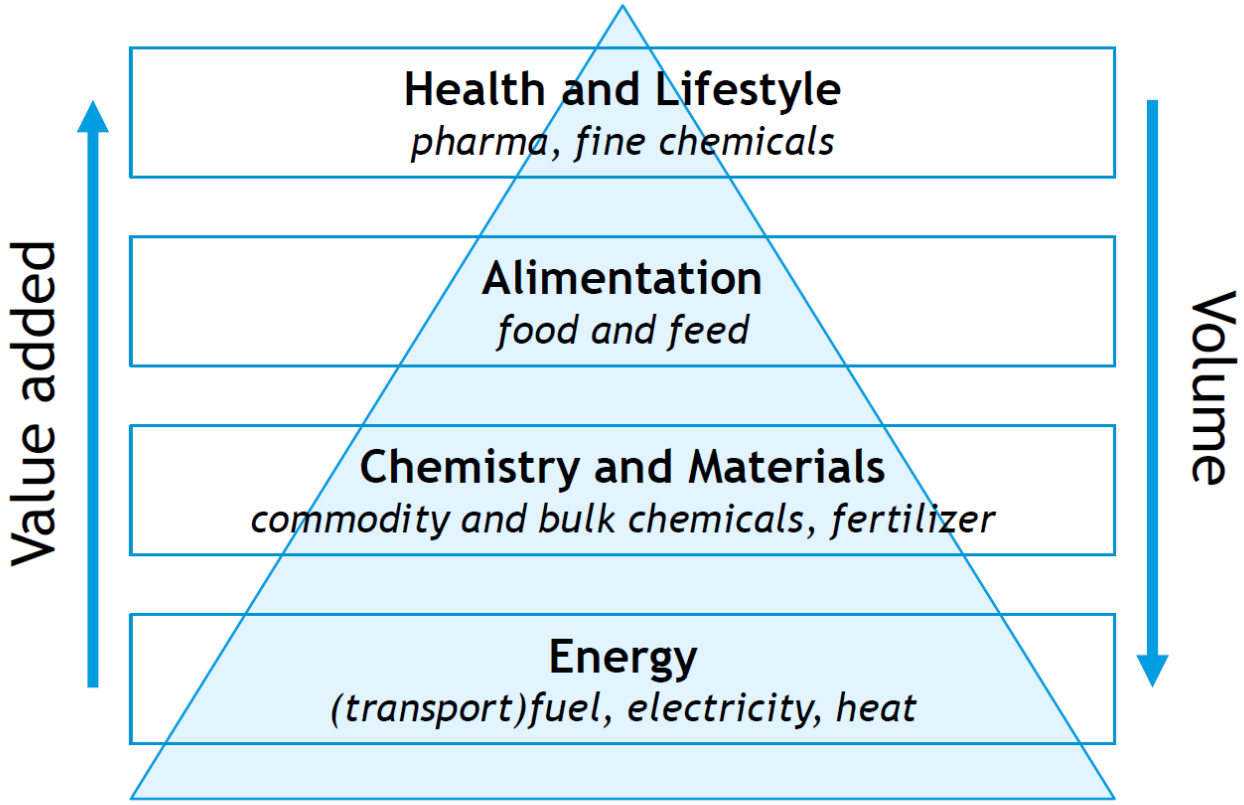

Figure 9: Value pyramid (Odegard, Croezen et al. 2012)

As a requirement of processing porcine blood into products, blood must be of high enough quality for a method that is suitable for the products. For example, blood fit for animal feed is not suitable for human consumption; conversely, blood for human consumption is apposite for both human foodstuff and animal feed industries. This rule is set by EU laws and regulations, which will be explained in subsection 2.2.6. Therefore, valorization technology starts with the equipment that can prepare porcine blood as a high quality raw material.

Blood collection by Anitec Hollow knife®

The pig slaughterhouse, in our study, currently uses the conventional bleeding technique of using a knife. While the pig remains stunned by an electric stunner, its throat is cut open, and blood runs out from the cutting hole. Blood obtained from this technique is likely to be contaminated by microorganisms from the environment rendering it only partially suitable for human consumption. Thus, a hollow knife was introduced to the market as a tool that can safely draw the blood out of the carcass with less chance of contaminating the blood with the environment (FAO 2008, ANITEC n.d.).

The hollow knife is a patented tool equipped with a vacuum pump to collect blood from the carcass (van den Nieuwelaar, van Gaal et al. 2005, FAO 2008). Details of this tool can be found in the patent of van den Nieuwelaar, van Gaal et al. (2005). The hollow knife and its equipment comply with both EU and US laws and regulations (van den Nieuwelaar, van Gaal et al. 2005, ANITEC n.d.), and blood obtained by this procedure is completely suitable for human consumption, which was the main aim of introducing this equipment to the slaughterhouse. Blood obtained from a hollow knife can be processed into either human foodstuff or animal feed depending on the wishes of the firm. The hollow knife company claims that their knife can hygienically collect around 85% of available blood, compared to conventional techniques, which can collect about 40% (Butina n.d.); thus, this machinery could raise the revenue of the company. There is no other commercial bleeding equipment that is able to collect blood to this extent; hence, if the company wants this equipment, there is only a single supplier; Butina Company, Denmark.

The machine is designed to be operated by one person to hygienically collect fresh porcine blood. As for its hygiene, the machine require hot water at 86°C to disinfect the knives. This is the main energy usage for this equipment. The collected blood is automatically mixed with a citrate solution to avoid coagulation and then mechanically pumped to a batch storage tank system allowing veterinary approval. Furthermore, the machine is equipped with the clean in place (CIP) system, a heat exchanger for blood cooling, to avoid bacterial growth, and a batch storage tank that helps in decreasing the risk of blood destruction in case of there is unhealthy blood contamination. If a veterinarian approves blood in storage tanks so that blood is suitable for human consumption the company can start valorizing it. Blood separation is a commonly used method after veterinary approval of collected blood. An example of a blood valorization production line can be found in Figure 10.

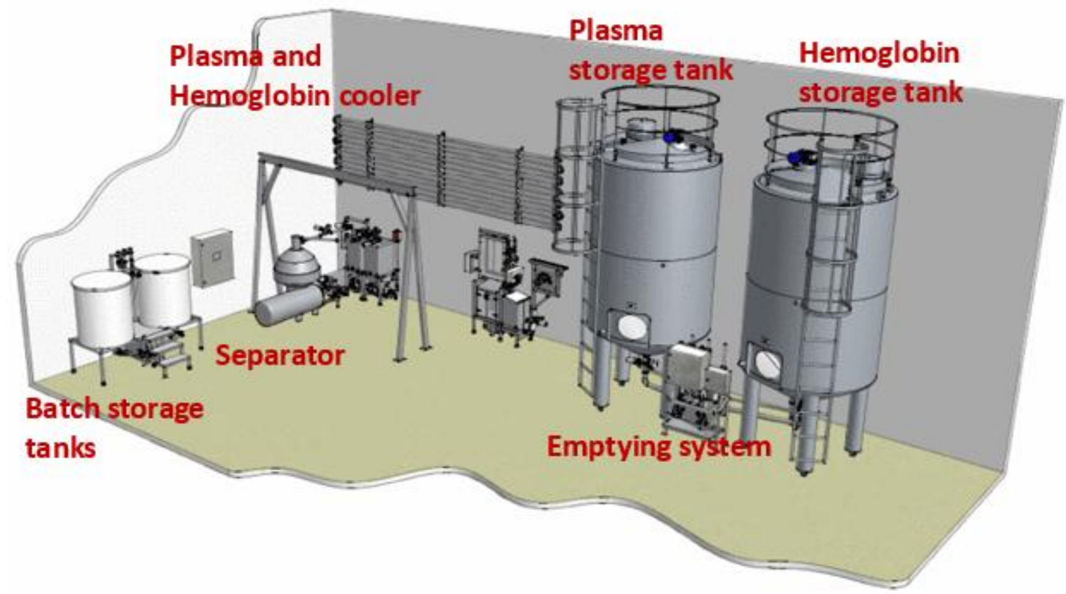

Figure 10: An example of blood separation production process (Butina n.d.)

Blood separation
A centrifugal machine is a predominantly used piece of equipment that aids in producing blood plasma and RBC (Wismer-Pedersen 2388). A centrifuge is employed by applying the principles of sedimentation and centripetal acceleration. When the solution is poured into the spinning chamber, the separation of blood into two phases will occur. Separation of blood into plasma and RBC is due to the differentiation in specific gravity of each constituent. It is more convenient to process RBC or plasma into products than valorize directly from collected blood; thus, this step is frequently implemented in the blood processing plant. The blood separation process can be considered as a preliminary step or a final stop. If the company stops their blood valorization line here, the finalized products are RBC and plasma that do not generate much value to the blood.

Concentrated red blood cells and plasma proteins
After blood separation, both of RBC and plasma will be kept in a clean and low temperature tank to avoid bacterial growth (Wismer-Pedersen 2388, ANITEC n.d.). As RBC and plasma consist of a high volume of water, concentrating them by partially removing water is a good approach because concentrated RBC and plasma have a higher selling price than non-concentrated. It helps in reducing the transportation cost, owing to lower weight of products, and it saves production cost in more advanced stages. Both the evaporator and ultrafiltration equipment are the most widely used apparatus to concentrate the RBC and plasma. Again, this step can be the final stage, but selling the concentrated products to other firms is not the only option that the company has; it can also process them to add more value to the products by applying advanced technology in the later stages.

Blood meal (animal feed or human foodstuff)
Blood meal is dry powder made from fresh blood, RBC, or hemoglobin and they are a good protein source (Chinprahast, Jantawat et al. 1995, Ofori and Hsieh 2012, Bah, Bekhit et al. 2013, Chandrasekaran 2013, ANITEC n.d., CSIRO n.d., Kitsavat and Khunajakr n.d.). In addition, it can be further processed into a protein or an iron supplement source for both humans and animals depending on the quality of the source.

The main processes of producing blood meal are blood coagulation, drying, and pulverizing. For the purpose of this report, RBC is the substrate for blood meal production because the company can gain more revenue by separating the plasma and selling it to other firms. Generally, RBC contains over 60% water, and it is mixed with an anticoagulant so it cannot clot and coagulate. Steam coagulation is a widely used method to make RBC coagulates. The main constituent of coagulated RBC is hemoglobin because it is denatured by heat and coagulated and only the protein chunk will be taken out by a decanter – the liquid part (water) is either thrown away or reused as steam. A disc dryer is commonly used for the continuous drying and pulverizing process of protein clumps. The alternative process of drying and pulverizing is spray drying that will be discussed in the next paragraph.

Spray drying blood powder, red blood cell powder, or plasma powder
Spray drying is the continuous transformation of feed from a fluid state into dried particulate form by spraying the feed into a hot drying medium (Gohel 2009). Spray drying t is not only an efficient technique, but also economical (Pares, Toldra et al. 2014). It has been reported that the spray dryer is more effective and economic than the commercial freeze

dryer (Desmond, Stanton et al. 2001, Gharsallaoui, Roudaut et al. 2007). Additionally, the spray dryer is better than the freeze dryer in most aspects; thus, the researcher chose to highlight the spray dryer in this research.

A spray dryer machine itself is not capable of processing porcine blood into either RBC powder or plasma powder; there needs to be a pre-process before spray drying. There was a study from Walter, Hertrampf et al. (1993) that successfully mixed bovine hemoglobin powder in cookies in order to fortify them with iron to increase the nutrition value of snacks for children. From this experiment, porcine blood that has similar chemical property with bovine blood might be used as supplement for iron deficient patient as well. An example of the outline of the spray dry process can be found in Figure 11.

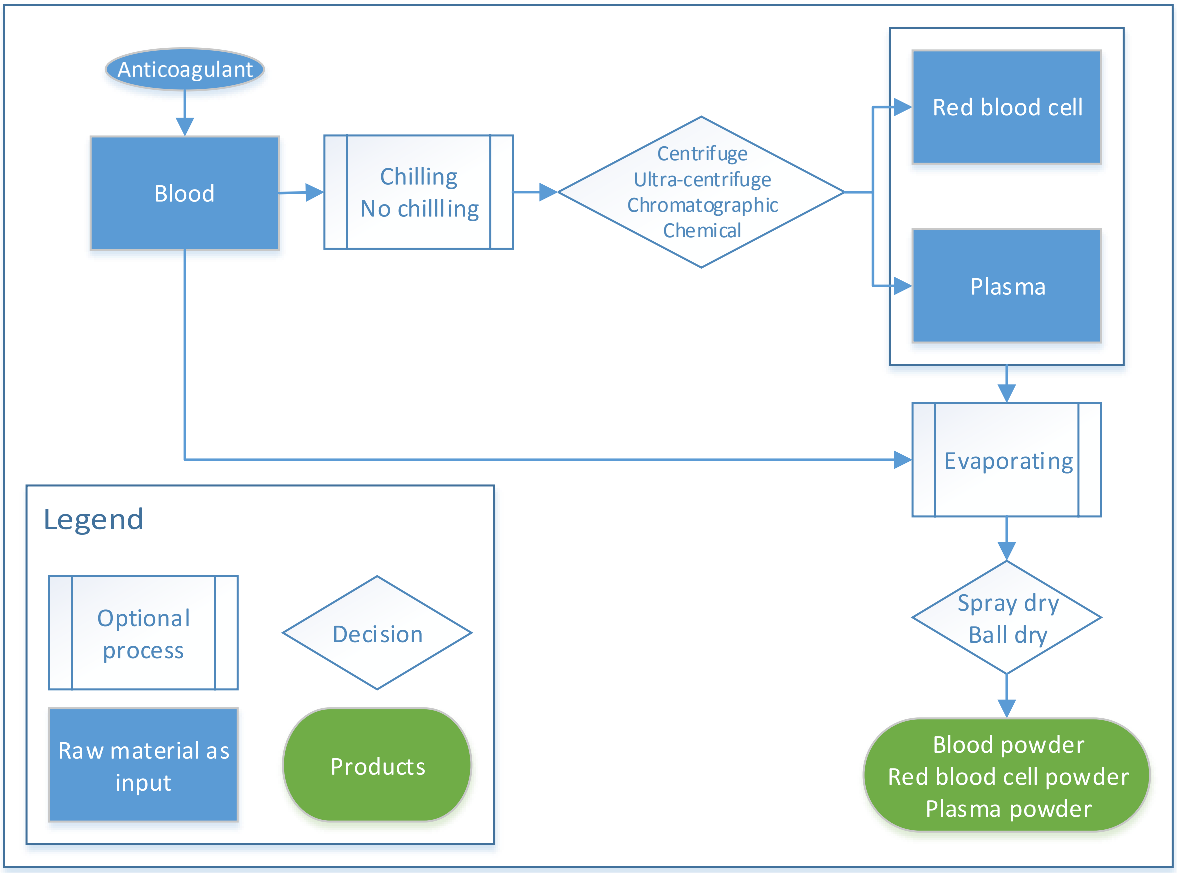

Figure 11: Spray dry scheme

From the above diagram, right after a veterinarian approves the blood in the storage tanks, there are two options available. First option is to go directly to the evaporator, and second, separation into RBC and plasma by a centrifuge, then evaporation as the next stage. However, evaporation is an optional process for the spray dryer. After concentration, the spray dryer will process the material into RBC powder, plasma powder, or whole blood powder depending on the input to the machine.

The spray drying process is well known for its high-energy consumption because water is evaporated from the incoming feed (blood) using heat, and this type of energy is not recoverable. Nevertheless, an evaporator can minimize energy loss from a spray dry machine because it can decrease the amount of water content from the blood before spray drying. An evaporator can reduce energy loss because the energy using in an evaporator is reusable by heat transfer equipment. Spray dried products typically have low moisture content so the company should store them in plastic sealed bags and keep in a cool and dry warehouse to prevent putrefaction or degeneration.

Isolation of blood and plasma proteins

In aforementioned section 2.1, blood consists of diverse types of proteins. On the positive side, the company can raise their revenue by further isolating these protein fractions and selling them, but the negative side is the cost of technology is expensive and requires expertise. An overview of this process is displayed in Figure 11.

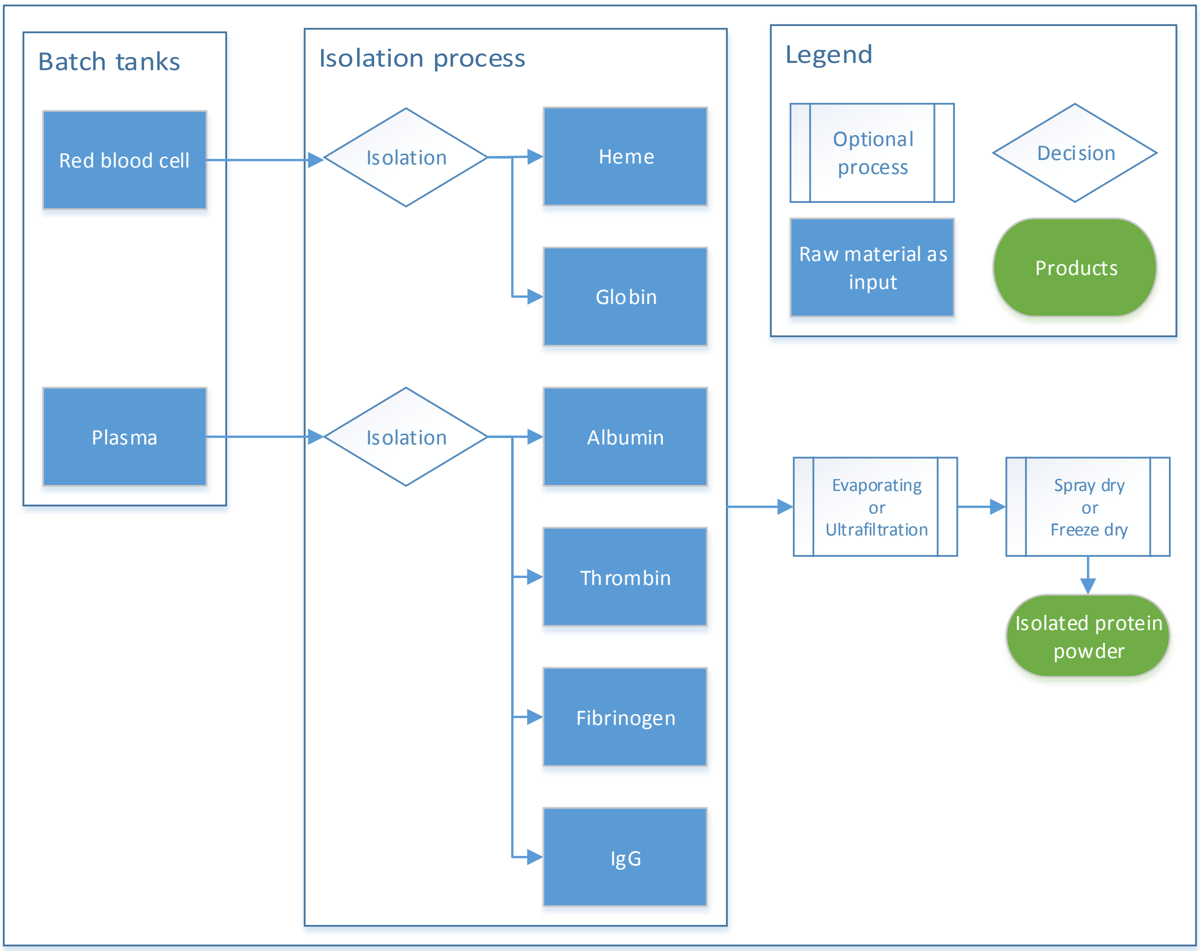

Figure 12: Blood isolation

Heme, globin, albumin, thrombin, fibrinogen, serum, and IgG are blood constituents that can be isolated from porcine blood (Liu 2002, Dàvila Ribot 2007, Álvarez, García et al. 2012, Ofori and Hsieh 2012, Bah, Bekhit et al. 2013, Chandrasekaran 2013, Ofori and Hsieh 2014, CSIRO n.d.). The company can gain more income by selling these components; however, more advanced technology is also in need to produce them. Several articles have been published detailing many treatments that can be used with an attempt to isolate each component, but most of these methods are either not cost-effective, or not well developed enough for application on an industrial scale (Álvarez, García et al. 2012, Ofori and Hsieh 2012, Pares, Toldra et al. 2014). Nevertheless, there are a handful of commercial products that are successfully sold (see Table 4). Therefore, if the company would like to compete in this market, it needs to develop their own expertise.

Bioactive peptide

In this report, the bioactive compounds are defined as compounds that can act as antioxidants, enzyme inhibitors and inducers, inhibitors of receptor activities, and inducers and inhibitors of gene expression in the human body while exerting beneficial effects beyond basic nutritional functions (Kris-Etherton, Lefevre et al. 2004, Bah, Bekhit et al. 2013).

Bioactive peptides are short sequence molecules consisting of approximately 2 to 20 amino acids and their bioactivities depend on their amino acid composition and sequence (Bah, Bekhit et al. 2013). From the studies of Ofori and Hsieh (2012) and Bah, Bekhit et al. (2013), bioactive peptides produced from plant and animal sources are reported to have antibacterial (Lee, Kim et al. 2001, Yu, Choudhury et al. 2001), opioid (Perpetuo, Juliano et al. 2003), antitumor (Qureshi, Colin et al. 2000), antioxidant (Kim, Kim et al. 2001, Liu, Chen et al. 2005), and angiotensin I-converting enzyme (ACE) inhibitory (anti-hypertensive) (Arihara, Nakashima et al. 2001, Matsui, Yukiyoshi et al. 2002) activities.

Porcine blood has an abundance of protein and is being studied as a source of bioactive peptides. Proteolytic enzymes are frequently used for producing bioactive peptides from blood. Enzymes of hydrolyzed peptide bonds with amino acids of proteins, result in a mixture of peptides of different molecular size and free amino acids (Bah, Bekhit et al. 2013). Enzyme substrate specificity is very important to hydrolysate functionality because the molecular size and polarity are influenced by protease specificity (Bah, Bekhit et al. 2013). Several researchers chose Alcalase enzyme as their proteolytic enzyme because it has a low cost and high yield (Bah, Bekhit et al. 2013). Furthermore, many researchers have attempted to hydrolyze porcine blood to produce bioactive peptides (Kris-Etherton, Lefevre et al. 2004, Yu, Hu et al. 2006, Wei and Chiang 2009, Xu, Cao et al. 2009, Gomes, Dale et al. 2010, Liu, Kong et al. 2010, Sun, Shen et al. 2011, Bah, Bekhit et al. 2013, Kitsavat and Khunajakr n.d.). Recent research is looking at antihypertensive and antioxidant properties. Even though bioactive peptides seem challenging to produce due to the required state of the art process and proficiency, Ofori and Hsieh (2014) have postulated that the blood hydrolyzation process can be scaled up to large-scale production.

2.2.4.2 Summary of valorization technologies

To valorize porcine blood into either human foodstuff or animal feed, blood should be first approved by a veterinarian. Technology that can be used to obtain high volumes of sterile blood, in which will be called veterinary approval blood in post-mortem, is Anitec hollow knife. A variety of products is structured by the value pyramid, the more advanced technology used to produce a product, the more revenue the company will receive. The researcher proposed seven valorization technologies, from the simplest method to the most advanced method. The overview of six levels production plan is illustrated in the Figure 13 below.

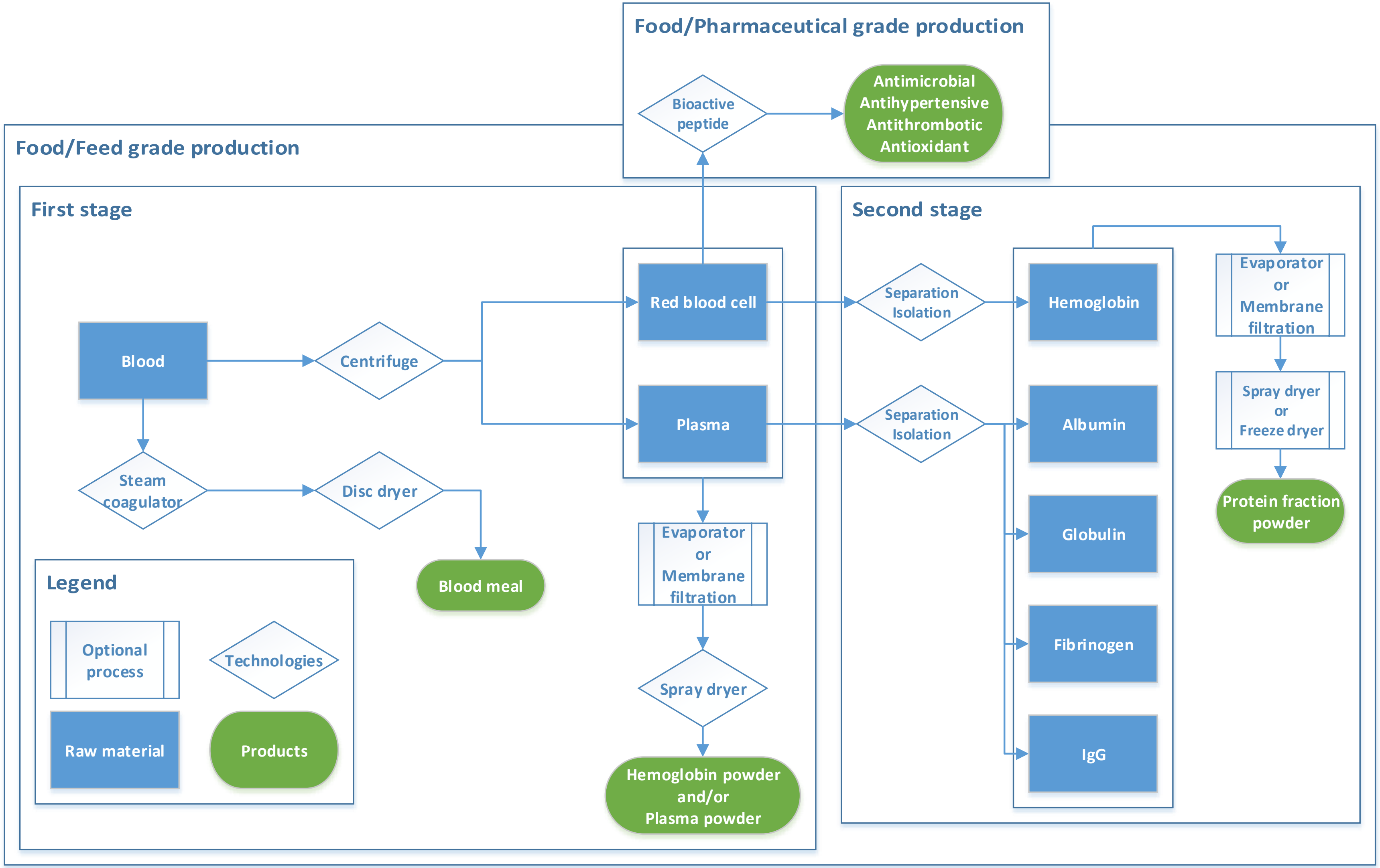

Figure 13: Whole valorization scheme starts from blood collection

2.2.4.3 Possible suppliers for valorization

The company can progress much faster by hiring other firms to support them with the expertise required. The company representative made a request that the firm want suppliers who are capable of providing after sales service, have a good reputation, and are reliable. Butina Company (Anitec), GEA Group, and I.C.F. & Welko Company are companies that met the criteria from the ABC slaughterhouse. Butina is the firm that owns the hollow knife patent (van den Nieuwelaar, van Gaal et al. 2005) so if the company decides to use this system Butina Company is the answer. In case the slaughterhouse is interested in spray dried products, both GEA Niro and I.C.F. & Welko excel in this process. Bioactive peptides and isolation of blood and plasma proteins process are required to have proficiency and expertise in this field; thus, the ABC slaughterhouse should develop their own knowledge on these processes.

2.2.5 **E**nvironmental

Environment is another key point for business these days, especial the agriculture sector. People are concerned more and more about environmental impacts. Examples of environmental factors are weather, climate change, waste management, scarcity of natural resources, recycling (Eiamsri 2011, HIA 2011, Johnson, Scholes et al. 2012, Nishadha 2012, Oxford Learning Lab 2012, Jurevicius 2013). Some of these environmental factors are directly linked to this study, including effects resulting from actions of other factors, such as technological or political, while some of the ecological factors are uncontrollable; hence, the environmental factor will be omitted from the study.

2.2.6 **L**egal

This section deals with laws and regulations related to porcine blood as raw material for valorization and valorized porcine blood products. The information from this section will help the researcher answers sub research question 3: “What EU laws and regulations are effective against porcine blood as raw material and valorized porcine blood?” Since there are several direct and indirect laws and regulations that the company needs to comply with, this section will include only the recently changed EU regulations.

First, sub subsection 2.2.6.1 reveals the laws and regulations that enforce the control of slaughtering, bleeding, and blood collection processes. Then, sub subsection 2.2.6.2 makes known requirements for processing blood into foodstuff and feed products. Not only the regulations that control quality of valorized porcine blood will be included in this study, but also the environment system, for example, packaging, residue, and additives, around the finalized goods will be discussed. A summary of relevant laws and regulations will be put at the end of this section, at sub subsection 2.2.6.3.

2.2.6.1 Laws and regulations for porcine blood as a raw material

This subsection intends to contribute in answering sub research question 3a: “What EU laws and regulations are effective against porcine blood as a raw material?” Thus, this subsection will emphasize the laws and regulations related to porcine blood as a raw material for processing into foodstuff and feed. Since relevant law is the backbone for every business, the technical aspects in sub subsection 2.2.2.1 and economic issues in subsection 2.2.1 are studied in relation to the enforcement of EU laws and regulations.

There are fundamental and specific requirements for slaughtering animals in relation to layout, construction, and equipment used in a slaughterhouse. These can be found in Regulation (EC) No 853/2004 (EC 2004b). In order to obtain porcine blood for processing into finished goods, the process and raw material (live pigs) needs to be controlled under law. Live pigs that a slaughterhouse is going to slaughter should meet the required minimum standard for animal health and welfare because their wellbeing is an important factor for quality and safety of finished products as stated by Council Directive 2008/120/EC (EC 2009a). However, this directive is just a guideline for all EU countries; there might be a more specific version from the government of the Netherlands. Since the directive is one form of regulation, a pig farmer can decide to follow this instruction, or not, which will affect the quality and safety of living pigs, when they are delivered to the slaughterhouse. In the case of products intended for human consumption, the slaughterhouse must comply with Council Directive 2002/99/EC (EC 2003), that details animal health requirements at various stages of production. With the aim of producing superior foodstuff or feed, a high quality of raw material is needed; thus, it is better to gain access to these suppliers.

The next step for obtaining porcine blood is the slaughtering process itself and this phase is the most crucial part for blood collection. The decision of which bleeding process to employ is made by the slaughterhouse depending on the types of final products, which can be either human foodstuff or animal feed products. The established regulation that lays down rules applicable for killing livestock, in this case pigs, was published in Council Regulation (EC) No 1099/2009 (EC 2009b).

The general requirements for slaughtering pigs are to kill them painlessly without any sign of stress and one of the requirements before killing pigs is to stun them (EC 2009b). There are two main commercial methods to anesthetize pigs. These are electrical stunning and using a high concentration of carbon dioxide (the whole list can be found in Annex I of EC (2009b)). Pigs must be killed while they are unconsciousness or stunned simultaneously. Whatever the stunning methods, pigs must be unconscious at the time of killing. However, there is no specific method developed for killing pigs, only anesthetizing techniques are technologically advanced. Also, slaughtering methods need to comply with EU laws and regulations in regards to safety and hygiene of animals as in Regulation (EC) No 178/2002 (EC 2002b); this regulation is also known as General Foodstuff Law Regulation (GFLR). With the proper equipment and killing technique, porcine blood is suitable for human consumption; for example, the conventional method using sharp knives to bleed pigs. The blood obtained from this method is partially suitable for human consumption due to prevention of contamination by microorganisms.

However, as discussed, there is only one commercial knife capable of drawing the blood out; the patented hollow knife by Butina (Anitec) Company (van den Nieuwelaar, van Gaal et al. 2005). To ensure the sanitation of slaughtering process as in Annex III of Regulation (EC) No 853/2004, slaughterhouses are required to disinfect their tools with hot water with a minimum temperature of 82°C or other systems with the equivalent effect. Further details in relation to cleaning and disinfection of knives of slaughterhouses can be found in EC (2001). The latest amendments directly affect the slaughtering process – but not for valorized products – are contained in Commission Regulation (EU) No 218/2014 (EC 2014b) and (EU) No 219/2014 . These two regulations amended ante-mortem and post-mortem inspections of the slaughtering process which is not related to blood valorization but for other organs. Since the scope of this research is limited to blood collection and the blood processing stage, therefore, the rest of involved law and regulations of slaughtering process and hygiene of foodstuff stuff, which can be found in Regulation (EC) No 852/2004 (EC 2004a), will not be included in this report.

2.2.6.2 Laws and regulations for valorized porcine blood

This subsection aims to contribute in answering sub research question 3b: 'What EU laws and regulations are effective against valorized porcine blood?' The valorized porcine blood products can be either human foodstuff or animal feed, because these two segments have potential for growth according to reports and information in subsection 2.2.2. Therefore, this subsection will focus on both human foodstuff and animal feed laws and regulations.

Not only valorized blood products are of concern here, but also equipment used for processing blood. According to discussions between the researcher and suppliers, they stated that their equipment complies with both EU and US laws and regulations. Furthermore, the company planned to hire these suppliers to help in constructing slaughtering lines in a new slaughterhouse. Therefore, the researcher assumed that there is no need to incorporate laws and regulations relating to equipment in this report.

Valorized porcine blood for human consumption
The fundamental requirements and definitions of human foodstuff can be found in GFLR (EC 2002b). This regulation provides the basis for the protection of human health, but does not cover for porcine blood or valorized blood products. Regarding valorization technologies in subsection 2.2.4, the list of future valorized products is: fresh porcine blood for human consumption, RBC, plasma, serum, concentrated RBC, concentrated plasma, hemoglobin, plasma protein, heme, globin, isolated plasma proteins, blood meal, spray dried blood powder, spray dried RBC powder, sprayed dried hemoglobin powder, spray dried plasma protein, and bioactive peptides. According to Article 3 in Regulation (EC) No 1333/2008, blood products and protein hydrolysates are not considered as food additives; thus, they fall into products of animal origin intended for legislation on human consumption.

Porcine blood and its derivatives, which are intended for human consumption, are mainly controlled by Regulation (EC) No 852/2004 (EC 2004a), (EC) No 853/2004 (EC 2004b), and (EC) No 854/2004 (EC 2004c). These three regulations are part of foodstuff hygiene legislation, which is often called the 'hygiene package.' Regulation (EC) No 852/2004 ensures the hygiene of foodstuff at all stages of the production process (EC 2004a). This regulation applies to food businesses from primary production up to, and including, sales to the final consumer, but does not cover for private domestic use. As the business plan of the slaughterhouse is B2B so this regulation has an effect on the firm. In addition, the traceability of products must abide by GFLR as the second pillar in the 'hygiene package', Regulation (EC) No 853/2004 lays down the hygiene rules for foods of animal origin for foodstuff businesses (EC 2004b). These rules apply to both unprocessed and processed products of animal origin, including blood, in which a supplement to the rules is laid down in Regulation (EC) No 852/2004. The slaughterhouse must comply with Article 5 (health and identification marking) of Regulation (EC) No 853/2004 in order to sell products of animal origin to other firms. Annex II of Regulation (EC) No 853/2004 lays down the relevant requirements for the slaughterhouse to follow, for instance, the method of marking a container during transportation. Regulation (EC) No 854/2004 lays down specific rules for the organization of official controls on products of animal origin (EC 2004c). This regulation states that food business operators shall provide the competent authority with all the assistance needed, covering the rules specified in both Regulation (EC) No 852/2004 and (EC) No 853/2004 in aspects of official control. These include specific controls of fresh meat, and audits of good hygiene practices, hazard analysis and critical control point (HACCP) based procedures. With the intention to assist food business operators to better understand the ‘hygiene package’, The European Commission had prepared several guidance documents posted on their website (EC 2013b). However, these documents did not amend any of the ‘hygiene package.’

In short, the slaughterhouse must comply with Regulation (EC) No 852/2004 in order to register and fulfill fundamental requirements as a first step. Then, Regulation (EC) No 853/2004 will come into action with the supplement rules of products from animal origin (valorized blood products); and Regulation (EC) No 854/2004 lays down the official controls so that the firm must provide assistance to the competent authority about specific controls of fresh meat and audits. The slaughterhouse needs to implement traceability from GFLR into action so that the valorized products can be sold to other firms. A simplified version of the ‘hygiene package’ for the slaughterhouse to grasp the concept of food hygiene can be found in guidance documents on the European Commission website (EC 2013b).

Valorized porcine blood as animal feed

The fundamental definitions and requirements of animal feed can be found in GFLR (EC 2002b). Similar to valorized blood products for human consumption, the European Commission lays down specific regulations for animal by-products not intended for human consumption in Regulation (EC) No 1069/2009 (EC 2009c) and (EU) No 142/2011 (EC 2011a).

Veterinary approval of porcine blood falls into ‘category 3’ material according to Regulation (EC) No 1069/2009, and it is also included in the list of feed materials in Commission Regulation (EU) No 68/2013 (EC 2013a). Blood obtained from the Anitec hollow knife® method is blood suitable for human consumption; however, it can be used for animal feed production – a catalogue of feed products is listed in Regulation (EU) No 575/2011 (EC 2011b). From the presented valorization technologies in subsection 2.2.4, the feasible feed products for the slaughterhouse are fresh porcine blood, blood meal, spray dried RBC, spray dried plasma, isolated blood proteins, and bioactive peptides. Porcine blood can be processed into these products with regard to Regulation (EC) No 1069/2009 that lays down the use of ‘category 3’ material in Article 14 (EC 2009c). Similar to the ‘hygiene package’, Regulation (EC) No 1069/2009 details feed hygiene specific rules for feed material, and official controls. The previous Regulation (EC) No 183/2005 lays down requirements for feed hygiene that still complies with Regulation (EC) No 1069/2009 as well (EC 2005). Soon after, Regulation (EC) No 142/2011 implemented animal health rules for animal by-products and derived products (EC 2011a).

In order to produce and sell animal feed products, the slaughterhouse must register an establishment with a competent authority as stated in Article 23 of Regulation (EC) No 1069/2009. Then the company can process porcine blood by pressure sterilization or by alternative methods authorized in Article 20 of the same regulation. Before selling feed products to other firms, the company need to implement traceability as described in Article 22. The company also need to monitor undesirable substances in feed according to Directive 2002/32/EC (EC 2002a). In recent times, blood products needed to declare crude protein and moisture (if it is over 8%) according to Commission Regulation (EU) No 68/2013 (EC 2013a). However, recently, there have been Swine Delta Coronavirus (SDCV) outbreaks in Asia and North America so that the European Commission announced Commission Implementing Regulation (EU) No 483/2014 with the intention to prevent an outbreak in Europe (EC 2014a). This regulation is not related to the slaughterhouse unless the firm imports blood products as a feed ingredient from those affected countries.

2.2.6.3 Summary of laws and regulations

Both human foodstuff and animal feed products have their own set of regulations that lay down specific rules in various subjects. Regulation (EC) 178/2002 is an exception because this regulation implements specific rules for both such as traceability. However, porcine blood and derived blood products are not in the scope of this regulation.

Products of animal origin intended for human consumption (valorized blood products) are controlled by Regulation (EC) No 852/2004, (EC) No 853/2004, and (EC) No 854/2004 for hygiene of human foodstuff at all production stages. European Commission amended ante-mortem and post-mortem inspection of slaughtering process of pigs exists to ensure a high level of protection of human health.

Porcine blood is included as feed material in a catalogue of Commission Regulation (EU) No 68/2013, and a list of feed products that the slaughterhouse can produce is in Commission Regulation (EU) No 575/2011. In addition, the slaughterhouse must hygienically process porcine blood, which is 'category 3' material as defined in Regulation (EC) No 1069/2009, according to feed hygiene requirements in Regulation (EC) No 183/2005 and a general requirement in Regulation (EC) No 1069/2009.

2.3 Porter's five forces framework

The ABC slaughterhouse is the second layer of the business environment of organizations (Figure 4). Porter's five forces framework helps a user to identify the attractiveness of interested industry or business, which depicted into terms of five competitive forces: the threat of entry, the threat of substitutes, the power of buyers, the power of suppliers, and the extent rivalry between competitors (Figure 14) (Porter 1979, Grundy 2006, Porter 2008, Johnson, Scholes et al. 2012). The five forces model, which is the most influential theory within business schools, is commonly used for assessing and analysis the competitive structure of industry (Grundy 2006). The knowledge from the five forces framework can help a strategist or a manager to gather prominent information for the company to contend in the concerned sector. The five forces model is a relatively useful instrument for evaluating the competitiveness as a first assessment of the interested industry, owing to highly prescriptive and rigid nature of the framework.

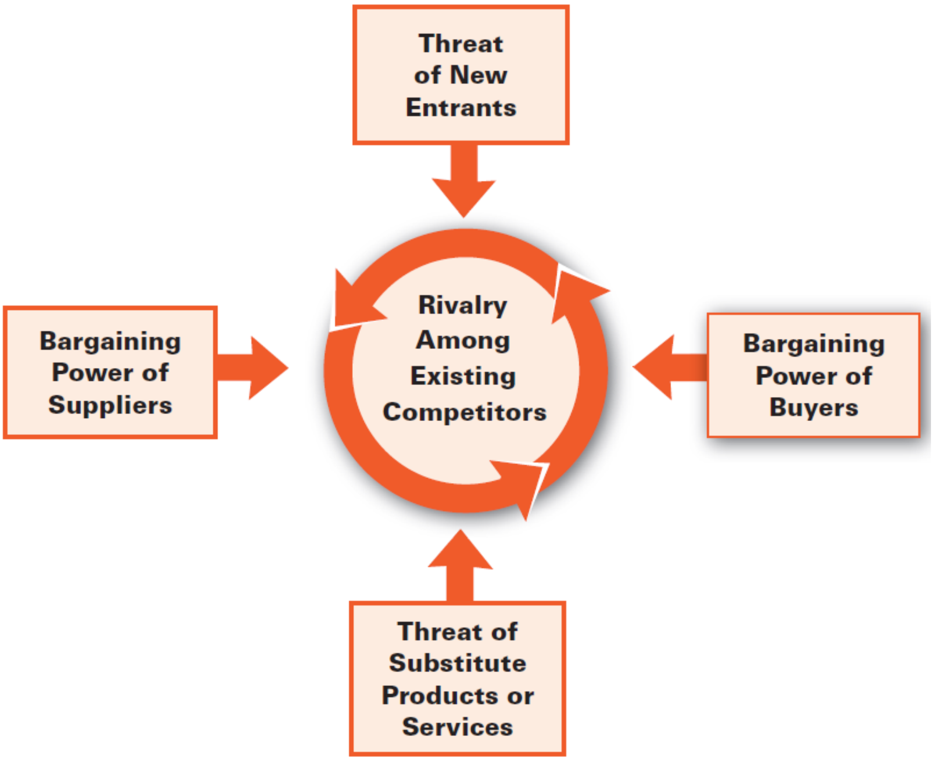

Figure 14: Porter's five forces model (Porter 2008)

Each of the five forces will be described in the following paragraphs for a thorough understanding of the model.

2.3.1 The threat of new entrants

When new entrants enter a new industry, they always bring new capacity and desire to gain market share, which often put the incumbents into a retaliation. Principally, when new entrants are diversifying from other markets, they also bring the existing capabilities and cash flows to the new market to gain market share.

The threat of entry depends on the height of entry barriers. The greater the threat of entry, the worse it is for incumbents in the market. An attractive market often has high entry barriers in order to deter the new competitors. If the entry barriers are low, it can be expected that there will be less retaliation from the incumbents in the market. There are seven entry barriers that the incumbent can make use of them as advantages over the new competitors (Porter 1979, Grundy 2006, Porter 2008, Johnson, Scholes et al. 2012). The seven major sources of entry barrier are Economies of scale, Demand-side benefits of scale, Customer switching costs, Capital requirement, Incumbency advantages, Unequal access to distribution channel, and Government policy

2.3.2 The power of supplier

Supplier in this context is not limited to material supplier, but also labor supplier, as well. Powerful suppliers can draw more profits out from their products or services (Porter 1979, Hitt, Ireland et al. 2008, Porter 2008, Johnson, Scholes et al. 2012). A powerful supplier will has an upper hand over purchaser if:

- The supplier is near to monopoly in the system.
- The supplier does not rely on a single industry. Many industries as customers mean that the supplier can sell their products through many sectors.
- The purchasers (industries) need to pay a high switching cost in changing supplier.
- The supplier provides different products from the market.
- There is no substitute for the product that the current supplier provides.

2.3.3 The power of buyer

In contrast to powerful supplier, powerful buyers can extract more money from suppliers either by demanding better quality raw material or by forcing down the price (Porter 1979, Hitt, Ireland et al. 2008, Porter 2008, Johnson, Scholes et al. 2012). Buyers will become powerful if they have better negotiating influence than other competitors do, especially, when they are price sensitive. A buyer can turn out to be a powerful purchaser if:

- There are few buyers in the market, and the buyer purchases in bulk that relative large compare to the size of a single vendor.
- Buyers can find a substitute or equivalent item in the market; they will go for a better one, or play one vendor against another.
- The switching cost from one vendor to another is not high in the viewpoint of the buyer.

2.3.4 The threat of substitute

If a special product from a single company reaped a large amount of money from the market, there might be a chance that competitors will reveal themselves with substitutes (Porter 1979, Hitt, Ireland et al. 2008, Porter 2008, Johnson, Scholes et al. 2012). A substitute is a product or service that can perform a similar function of the industry's product to satisfy the need of customers. Coca-Cola and Pepsi are a good example of substitutes of soft drinks, when there is no Pepsi, customers may choose Coca-Cola or others to satisfy their need. With the capability of substitution, the ceiling price of the product is also limited by the price of substitutes. If both of them have similar quality and price, customers tend to choose the cheaper one. Thus, profitability of the product is limited by the substitute. For the substitute, the threat of it can be high if:

- The trade-off of price-performance is acceptable for offered industries. For example, if a pig farmer would like to change pig feed from company A to company B, he needs to compare the price and performance of pig growth from the both firm. If there is slightly different, buyer might choose the cheaper one.

- The switching cost of substitute is low; it is easier for the customer to change the buying source. From the same example, the cost of switching from company A to company B is almost zero due to there is no preferential for equipment or instruction of use.

2.3.5 Rivalry amongst existing competitors

It is undeniable that there are competitors in every market. However, rivalry may bring good fortune to the industry if they compete others in a profitable way (Porter 1979, Porter 2008, Johnson, Scholes et al. 2012). The profit that can be reaped from the market is also depend on the intensity of the rivalry, which will be the highest if:

- There are abundant of competitors in the same market, which these competitors are also almost equivalent in size and power. Frequently, there will be a firm or two who want to be a leader in the market.
- The growth of the market is slow; competitors will fight for the market share.
- There are high exit barriers. When unrecoverable costs are large or recoverable costs are small, these are a sign of high exit barriers, since firms cannot earn their capital back when they want to leave the fight. Thus, they will put all of their effort to gain market share.
- A particular company not only aims for economic performance, but also for their pride and fame. This type of company will endeavor to be a leader in the market.

2.3.6 Summary of Porter's five forces

Porter's five forces model consists of threat of entry, the power of the buyer, the power of the supplier, the threat of substitute, and rivalry amongst existing competitors. The five forces are used to check on an attractiveness of interested market before and during operation in that segment. The threat of entry can be used to check the potential of becoming an incumbent in the later stage. The power of the buyer can explain why some of the buyers are able to force down the purchasing cost while others cannot. The power of the supplier can reveal the strategies behind the suppliers or manufacturers that enable them to attain more profit from customers. The threats of substitute show management how and where are threat come from. The earlier the management knows about forthcoming threats, the sooner they can prevent an attack from that threat. As the last force, rivalry amongst existing competitors is allowed the management team to grasp the current situation of the market and predict the next move of competitors. By realizing and utilizing Porter's five forces framework, this is almost certainly that the company can survive through the fierce market competition nowadays.

Even though the Porter's five forces seems to be a perfect tool for analyzing the opportunity of a new business, but there is few flaw in the model. From the study of (Dyer and Singh 1998, Dulčić, Gnjidić et al. (2012)), they found that the model did not include collaborative potential between firm into account, which the collaboration among firm can frequently found in business nowadays. As postulated by (Grundy 2006), these are limitation of the five force framework:

- The value chains of industries were overgeneralized, i.e. buyers can be either intermediately, consumers, or supplier at the same time.
- The five forces framework does not link the encounter problems with management solution.
- The model was invented since 1979, which was over three decades past, thus the industry structure is not the same, for instance, nowadays industry boundaries is more fluid, unlike the industry entities back then.
- In the original article, it contained too much jargon, which may troublesome for the practitioner as manager.

Nonetheless, the other factors still exist in the market such as law and regulation, technologies, environment, and social. These factors can influence the situation and result in an unexpected circumstance for the company. Thus, it would be better if responsible persons can combine Porter’s five forces framework with other elements, such as, a SWOT analysis, to enhance the accuracy of the assessment.

2.4 SWOT analysis

To answer the economic sub research question, theories about business strategies such as the PESTEL framework, Porter’s five forces, and a SWOT analysis are necessary. The PESTEL framework is a useful tool for a company that is going to step into new investment territory (Johnson, Scholes et al. 2012, Nishadha 2012), while the five forces framework is used for assessing the attractiveness of the interested market. Even though the PESTEL framework excels in the analysis of business situations, relying on one single tool is not a good practice. Hence, combining a SWOT analysis with Porter’s five forces in the analysis and decision-making step can further improve the outcome.

A SWOT analysis is widely used as an instrument in strategic planning (Houben, Lenie et al. 1999, Dyson 2004, Nishadha 2012, Yuan 2013). The system consists of four elements; **S** refers to strengths; **W** refers to weaknesses; **O** refers to opportunities; and, **T** refers to threats. Strengths are advantages that the company has over competitors; Weaknesses are disadvantages that company need to address in order to catch up with competitors; Opportunities are a future trend where a company can take advantage; Threats are external actions or movements likely to cause negative impact. Strengths and weakness are internal characteristics or organizational capabilities; while opportunities and threats stemmed from outside the company or external factors. A TOWS matrix is often used to analyze the situation of a project. The matrix always appears in a tabular format (see Table 6).

Table 6: TOWS matrix template

	Opportunities	**Threats**
Strengths	S-O strategy	S-T strategy
Weakness	W-O strategy	W-T Strategy

In order to utilize a TOWS matrix, the company or management need to identify four factors or SWOT first because it will serve as fundamental information in order to select the suitable strategy at a later stage. There are four strategies that can be derived from the matrix: S-O, S-T, W-O, and W-T. These strategies utilize advantages and disadvantages of the company to enhance success rates (Weihrich 2382, Dyson 2004, Nishadha 2012).

1. *The S-O strategy* is an ideal position for every company because they maximize both strengths and opportunities. This means that a company can utilize their strengths to acquire any available external opportunities from a project.
2. *The W-O strategy* is a strategy whereby the company minimizes its weaknesses and maximizes the opportunities. The company might lack the capability to do something by themselves, but they can exploit the opportunities in a market.
3. *The S-T strategy* is to use the company strengths to deal with threats in the environment. A decision maker will compare company strengths and environment threats to determine solutions or strategies.
4. *The W-T strategy* is a strategy that aims to help the company by minimizing both weaknesses and threats. This is a precarious situation, in which a company might need to choose liquidation; thus, a number of strategies might arise from this situation in order to recover and help the firm.

3. Methodology

This chapter will describe the specific research strategy and the methods which were chosen to gather the appropriate data from the ABC slaughterhouse. This chapter acts as the backbone of the empirical research because it provides guideline and procedure for successful data gathering phase. The researcher will analyze the data from the empirical research phase and discuss with the company for selecting the highest potential valorized product in order to search for feasible valorization technologies.

3.1 Data sources

Three different of data sources were used for the empirical part: reality, documents, and literature (Verschuren and Doorewaard 2010). The reality source is used as the main input because the researcher can obtain data by unobtrusive measures since there is little or no influence on the research object by the researcher (Verschuren and Doorewaard 2010). The other two sources were used to provide additional relevant information that might not be able to collect by the reality. In brief, the reality source was used as a primary data source, and documents and literature were used to provide additional relevant information as secondary data sources. There are advantages and disadvantages within every data sources (Verschuren and Doorewaard 2010), which will be shortly explained in the next paragraphs.

The most important advantage of reality source information is that a researcher can obtain data by unobtrusive measures, which is a direct measurement (Verschuren and Doorewaard 2010). In the specific situation, a researcher can collect adequate and detailed information according to his interest, which is required to answer to the research questions. A notable disadvantage of reality is that obtained data can only serve as a data source not a knowledge source, which is limited the significance for the majority of research issues. For that reason, combined unobtrusive measures with other sources of information can overcome this weakness (Verschuren and Doorewaard 2010).

The initial intention of using both documents and literature as secondary data sources is to provide a different approach to the various sources of information. The advantage of documents, for example, as data source is that the researcher can gain access to specific public documents, which is, sometimes, only for internal use in the organization (Verschuren and Doorewaard 2010). Documents are durable source of information that the researchers can refer to constantly, and frequently available in large quantity of variety range (Verschuren and Doorewaard 2010). At the same time, if the researcher has the large amount of documents, searching and selecting through the pile of information are always time-consuming.

Literature source mostly contains specific information and theories, which often consider being a knowledge source. However, it can also serve as a data source if the researcher can draw out the data from the literature as if he is an author (Verschuren and Doorewaard 2010). Advantage of this type of data source is that literature regularly found in many forms with specific knowledge, such as, scientific articles, monograph, or specialist books (Verschuren and Doorewaard 2010). Knowledge is being updated all the time; thus, the latest version of literature is better to use as reference than an outdated one. The language or jargon that often found in the books can be a disadvantage, because of difficult to understand for a person who is not get used to the jargon, for example, an incumbent, which means a company or organization that is currently in the interested market and has market share of the interested market. The researcher should not put too much confidence in the existing literature, because authors might work with the previous insight of others, and not generating new knowledge or insight (Verschuren and Doorewaard 2010).

As stated above, three data sources have its own strength and weakness, which need to take into account when assessing the information. The ABC slaughterhouse was selected as a reality and documents data source, which the slaughterhouse is assumed to have information and specific numbers and figures for a researcher to observe and obtain. The documents related to the slaughterhouse and valorization of by-products and waste streams were in a part of data gathering process. However, some specific numbers and figures can only be obtained from the ABC slaughterhouse, as of the information is confidential. The researcher will use literature related to valorization, slaughtering process, law and regulation, and economics from the specialist journals, reports to check with the obtained data from the reality source information.

3.2 Research strategy

The research strategy is the approach that the researcher will select specific methods in order to gather the relevant data and material to answer to the research questions (Verschuren and Doorewaard 2010). This research aims to valorize porcine blood from the ABC slaughterhouse in the Netherlands. A pig slaughterhouse, usually, oversees the hidden value of by-products and wastes from their daily process. The company can save its expense and increase the income at the same time by valorizing their potential by-products or wastes (i.e. porcine blood).

Propositions were developed from reviewed literatures related to valorization technologies, economic, and laws and regulations. The researcher can depict and compare the most feasible process for the company from the knowledge from literatures. The empirical research step aims to gather the actual figure and number of data from the ABC slaughterhouse, and study the applicability of the theory created during the literature study phase. Hence, when the quantity and quality of porcine blood are obtained, the specific laws and regulations that need to be obliged and the economic aspect as of investment were combined, the outcomes concerning the feasible valorization technology, economic, and laws and regulations will be suggested according to the theory (de Vaus 2001).

3.2.1 Data collection

The “observation” is a manner of gathering the data by perceptual process so that to observe is to watch at, listen to, touch, taste, or smell something, attending to details of the resulting perceptual experience (Evaluation Research Team 2008, Bogen 2013), and such its effectiveness heavily depends on the observation skills of the observer (Taylor-Powell and Steele 1996, USAID 1996, Evaluation Research Team 2008, Bogen 2013). The researcher used an observation strategy for the main data source, reality. **Both of direct and indirect observation methods are what the researcher was using in this research.** Together, direct and indirect observations are qualitative and quantitative research methods. Source of the data is collected from several production points and from the documents and files in the system, in the functioning pig slaughterhouse in the Netherlands, which predominantly study in XYZ area, particularly the ABC slaughterhouse.

Observation can be done in two methods, direct and indirect. Direct observations are the processes of observers watching the events, behaviors, processes, or actions at the activity sites as they occur; for instance, watching a worker cutting off a lung from a pig carcass to determine the preciseness of his cutting skill and intention. The direct observation is a time-consuming process, because the observer needs to watch the interest subjects all the time until he obtained enough information from the subjects (Taylor-Powell and Steele 1996, USAID 1996, Evaluation Research Team 2008).

In contrast, the indirect observation is the processes that observers are watching the results of processes, actions, events or behaviors at the activity sites (Evaluation Research Team 2008); for example, collecting the red plastic crates filled with unwanted material from trimming legs to determine the quantity and quality of pig carcasses. The indirect observation is relatively quick due to the short process of collecting data at the several predetermined designated points. Benefit of this method is the researcher can gather a large quantity of data in a short time, but the weakness of this method is the reliable of the data (Taylor-Powell and Steele 1996, USAID 1996, Evaluation Research Team 2008). If the observer knows the root or process of the collected data, he can overcome the weakness of data.

Overall, both of the direct and indirect observations have their own strength and weakness, the observer need to select the most appropriate method to aid him in the empirical research phase. The researcher decided to combine both of direct and indirect observation methods to maximize the outcome of empirical data gathering at the ABC slaughterhouse. In order to gather the useful and reliable information, the research decided to combine the strength of each method to compensate their weakness; thus, the crucial information can be drawn out from the observed facility.

3.3 Empirical research

The data collection methods that were described in aforementioned subsection 3.1 and 3.2 are moderately abstract and difficult to apply. In this section, these theories will be put into use in observing at a pig slaughterhouse to obtain information from the slaughterhouse and suppliers for analysis and selection the suitable valorization technology.

3.3.1 Slaughterhouse

This research focuses solely on the slaughtering process because it generates a huge amount of by-products and wastes. The researcher had observed and collected information for three full days, 19 February 2014, 5 March 2014, and 12 March 2014. The slaughtering line consists of multiple stations that serve different purposes. Only stations that related in by-products and wastes generation will be discussed in following paragraphs. The related station will be described in order from the pigs receiving station until storing carcasses in the chill room.

According to EU law and regulations, most of the cut off parts from the slaughtering process are category three product. However, not all of the category three products can be sold to other firms. Hence, the category three products can be further divided into sellable and destruction types. The sellable parts can be sold to other firms to generate income while the destruction portion is required money from the company to get rid of it. The category three silo is where the company stores the destruction portion.

The researcher used several containers to collect the cut off parts as indirect observation. At the same time, he also checks for weight of organ containers as direct observation. Because the production line is long, the whole production line is illustrated in **Error! Reference source not found.**.

Recapitulation, the observation methods and techniques can be used to investigate the amount of products, by-products, and wastes. To simply divide the cut off parts, the researcher had classified them into two groups. The first group is the organs that generate income to the company, and the second group is the organs that the slaughterhouse needs to pay for eliminating them. The first group consists of human consumption blood, cutting hole, the first reproductive organ, testis, uterus, spleen, liver, lung, trachea, heart, diaphragm meat, kidney, fat, blood meat, lard, diaphragm, and spinal cord. The second group comprises of hair, nail, fallen red organ, the second reproductive organ, tonsil gland, gallbladder, fallen head, and cut off parts from all three quality trimming stations. The researcher had successfully transferred data from the company's documents to the computer and combined it with information from the company system. A full list of data from the company system and observation can be found in Table 7 and Table 8.

3.3.2 Suppliers

One of the criteria about the suppliers that the slaughterhouse wants to be their suppliers is to situate in Europe. Butina Company, GEA Group, and I.C.F. & Welko Company are feasible suppliers for this project, but the researcher successfully contacted with representatives from the first two companies; thus, this subsection discussed about equipment information that can apply in valorization project from them.

3.3.2.1 Butina (Anitec) Company

According to the slaughterhouse representative, the new pig slaughterhouse will have the capacity of slaughtering at a rate of 810 pigs per hour – in total around 7,200 animals per day. The researcher contacted the Butina Company asking for suggestions for the hollow knife machine, and the 'RotaStick® 14' sticking carousel was proposed because it has the capability and state of the art functions. The estimated price from sales person for this equipment is €770,000. An example picture of a hollow knife machine 'RotaStick® 14' is displayed in Figure 15.

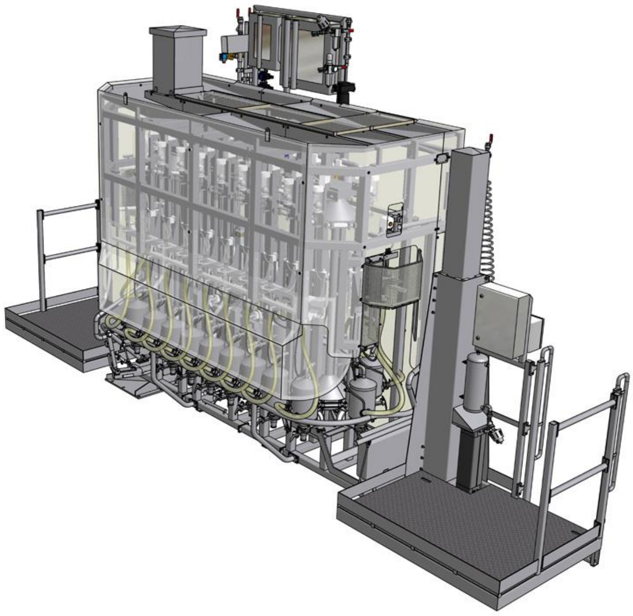

Figure 15: 'RotaStick® 14' sticking carousel plant (Butina Company)

Additionally, the representative proposed a centrifuge to use with hollow knife machine at a cost of €308.000. However, the provided information of this centrifuge from the supplier is not adequate to implement in the valorization process; thus, this equipment was excluded from further investigation and implementation.

3.3.2.2 GEA Group

GEA Group consists of several companies that contribute in this project. The researcher contacted sales persons requesting for recommendation of suitable equipment for blood valorization. They suggested a centrifuge, an evaporator, an ultrafiltration, a steam coagulator, a disc dryer, a small spray dryer, and a large spray dryer as suitable equipment for valorization, and estimated prices of these machines are €300,000, €650,000, €300,000, €300,000, €650,000, €900,000, and €1,500,000, respectively. The GEA representatives also provided that an estimated maintenance cost is usually 8% of a machine cost on a yearly basis. The cleaning cost is depended on chemical option of the slaughterhouse. Due to several addition equipment for the valorization production line, the company needs to include an estimated extra cleaning hour that is one hour per day per machine.

3.4 Reliability and validity

Reliability and validity are indicators in determining the quality of research (Yin 2009). Both reliability and validity were mentioned in earlier lines. Both of them will be discussed in this subsection.

Reliability refers to conducting the same research with the same procedure from a previous researcher, which will arrive at same result and conclusion (Yin 2009). This research was conducted with systematic planning and consistent way. Quantitative data collection methods were using with care. The researcher combined the methods and techniques of data gathering to mitigate the error that might occur in field research phase. Furthermore, the procedure of data collection in section 3.3 is completely described as detailed as possible.

The construct validity refers to a situation that the researcher cannot develop a sufficiently effective set of measures and the defective processes are used to collect the data (Yin 2009). Multiple data sources were used to ensure the validity of the data. Not only several sources were used in data collection, but also three repetitions of the data collection in empirical research phase were performed to check on the consistency of the data. However, it is inevitable to control the whole slaughtering process to operate without fluctuation or error; consequently, there is fluctuation of quantitative data from time to time, such as, line break down that cause in stopping the slaughtering process. Nonetheless, the fluctuated data remains in the trend lines according to previous data collection records, which proves that the obtained data is valid.

4. Results and analysis

In this chapter, the results of empirical research and the literature study are presented and analyzed. This chapter aims to answer research question 2d: "Among the currently used valorization methods and the proposed methods, which provide the greatest economic benefits for the slaughterhouse?"

For the purpose of this research, the answers are approached through these steps. First, the presented technologies from subsection 2.2.4 are screened by effective legislation from subsection 2.2.6, along with the company requirements. Then, the selected valorization technologies are analyzed and compared for their costs and profits by applying knowledge from subsection 2.2.2. Simultaneously, information from the prior step (technological and economic) is combined and analyzed by Porter's framework from section 2.3 and a SWOT analysis from section 2.4 using a TOWS matrix as a tool.

4.1 Analysis of the results

The data obtained from empirical research phase has been successfully transferred into the computer, which can be found in Table 7, Table 8, and

Table 9. Table 7 and Table 8 displayed whole lists of organ and their weight while

Table 9 emphasized on porcine blood data.

Table 7: List of organs and the total amount in kg from the system in the slaughterhouse

Name	19 Feb 2014	05 Mar 2014	12 Mar 2014
Aorta pig	7634.4	5593.4	5333.2
Blood hum	2820.0	2558.5	6396.9
Blood meat	6499.1	9815.5	6343.4
Blood non hum	6409.7	3375.5	9300.7
Category 3	6812.5	1592.5	1917.4
Diaphragm	5946.2	9477.0	9946.8
Diaphragm meat	9161.1	8520.4	1456.2
Fat net	6247.1	1324.8	4600.9
Hair	3298.6	2238.4	7205.1
Heart	6077.8	2960.3	6691.5
Intestine (dirty)	1864.7	3735.5	7763.8
Kidney	6211.6	8364.5	5909.4
Lard	4043.4	1303.2	9125.0
Liver	5626.6	8684.0	2888.2
Liver (white spot)	4023.5	2539.6	2045.0
Lung	5502.6	4491.5	4451.2
Pancreas	5665.6	9592.3	6068.9
Penis	5264.8	1641.6	2075.1
Scrape fat	5593.1	9151.1	2203.3

Spinal cord	9628.6	9988.2	3652.4
Spleen	1688.1	8938.6	3085.3
Stomach	5286.7	4942.6	4303.8
Testis	6995.6	9732.2	1433.7
Throat	4399.9	4593.6	2425.1
Tongue meat	5691.6	3323.8	6336.1
Urinary bladder	4383.0	8064.1	3916.9
Uteri	8641.1	6817.3	9751.8
Total	**151,417.04**	**153,359.92**	**136,627.22**

Table 8: List of organs and the total amount in kg from the observation in the slaughterhouse

Name	19 Feb 2014	05 Mar 2014	12 Mar 2014
Breast bone	8.9	185.4	331.9
Breast bone (abscess)	435.7	335.1	492.5
Diaphragm	174.4	254.1	412.5
Ear	395.1	147.9	422.4
Fat	417.7	238.9	279.3
Gall bladder	451.4	118.9	397.8
Half carcass	371.5	261.5	248.6
Ham (abscess)	166.7	339.6	235.1
Ham (broken)	3.9	91.9	411.3
Ham (manure)	433.5	425.4	250.1
Head	248.9	233.8	168.2
Head fat	499.1	332.4	30.5
Kidney	467.1	104.0	238.0
Lard	379.2	374.4	409.2
Liver	354.8	38.9	247.6
Loin (abscess)	86.6	299.4	15.4
Loin (broken)	296.6	150.4	394.1
Lung + organ	272.6	448.9	132.5
Nail	47.2	358.7	204.5
Penis 2	415.1	488.3	474.8
Penis 2 fat	166.8	208.5	444.9
Post mortem	397.1	426.3	191.4
Red organ	353.0	270.7	456.9
Rubbish	358.2	122.3	415.7
Shoulder	285.7	76.2	317.5
Shoulder (abscess)	151.9	399.9	443.7
Shoulder (broken)	443.0	61.0	328.8
Skin	363.7	318.1	399.8
Spleen	102.0	212.8	137.9
Tail	196.6	149.5	87.1
Tail + Loin (abscess)	9.6	458.7	231.3

Tail + Loin (broken)	8.1	170.5	8.3
Tail (abscess)	328.9	148.9	145.0
Tail (manure)	97.2	215.4	407.9
Testis	79.0	180.8	230.3
Tonsil	22.3	287.8	413.4
Trachea	255.1	489.3	459.4
Trotter	442.9	223.0	453.0
Trotter (abscess)	383.6	70.9	444.4
Trotter (broken)	464.5	466.4	209.3
Total	**10,835.3**	**10,184.9**	**12,022.4**

Table 9: Porcine blood collection data on kg on daily basis

Date	Amount of pigs (animals)	Blood (Human consumption; kg)	Blood (Destruction; kg)	Total blood (kg)
30/12/2013	5,350	3,335	9,231	12,566
31/12/2013	4,672	8,497	12,036	20,533
02/01/2014	4,933	8,601	9,681	18,282
06/01/2014	5,591	7,863	10,877	18,740
07/01/2014	4,577	4,917	12,594	17,511
08/01/2014	5,664	6,961	11,312	18,273
09/01/2014	5,946	4,133	10,358	14,491
10/01/2014	5,828	7,308	12,800	20,108
13/01/2014	5,954	10,813	8,860	19,672
14/01/2014	5,038	3,241	10,025	13,267
15/01/2014	5,098	8,912	12,377	21,289
16/01/2014	4,981	5,774	10,716	16,490
17/01/2014	4,891	8,168	9,102	17,270
20/01/2014	5,116	10,524	10,933	21,457
21/01/2014	4,530	11,850	10,945	22,795
22/01/2014	5,342	11,314	11,782	23,096
23/01/2014	5,055	5,570	10,769	16,339
24/01/2014	5,071	11,555	12,697	24,252
27/01/2014	4,938	8,929	8,976	17,905
28/01/2014	5,194	10,423	11,206	21,629
29/01/2014	5,891	8,738	11,034	19,772
30/01/2014	5,554	5,762	9,423	15,185
31/01/2014	4,936	10,238	12,764	23,002
03/02/2014	5,448	10,654	8,458	19,112
04/02/2014	4,602	7,136	12,984	20,121
05/02/2014	5,335	8,060	10,372	18,432
06/02/2014	5,068	5,489	12,656	18,145
07/02/2014	4,887	4,735	11,218	15,954
10/02/2014	5,058	10,834	8,956	19,790

11/02/2014	5,438	10,918	10,993	21,911
12/02/2014	4,625	5,423	12,600	18,023
13/02/2014	4,802	10,844	11,012	21,856
14/02/2014	5,766	4,522	11,357	15,879
17/02/2014	5,885	7,881	12,119	20,000
18/02/2014	4,906	5,455	10,791	16,245
19/02/2014	5,073	7,566	8,787	16,353
20/02/2014	5,852	3,054	11,181	14,235
21/02/2014	4,537	10,040	12,626	22,665
24/02/2014	5,974	3,954	9,174	13,128
25/02/2014	5,233	5,481	11,257	16,738
26/02/2014	5,843	9,914	9,115	19,029
27/02/2014	5,032	9,061	11,175	20,236
28/02/2014	4,539	8,484	12,553	21,037
04/03/2014	5,963	9,633	8,633	18,266
05/03/2014	4,756	6,895	8,493	15,388
06/03/2014	5,681	8,240	12,912	21,152
07/03/2014	5,206	9,954	12,816	22,770
10/03/2014	5,887	11,436	11,719	23,154
11/03/2014	5,674	8,683	10,775	19,458
12/03/2014	5,085	3,798	10,226	14,025
13/03/2014	4,889	11,366	8,093	19,459
14/03/2014	5,809	9,271	12,709	21,980
17/03/2014	4,505	3,423	9,551	12,974
18/03/2014	5,523	9,897	8,564	18,461
19/03/2014	5,723	4,194	8,940	13,134
20/03/2014	5,563	3,114	10,576	13,689
21/03/2014	5,635	4,707	9,341	14,048
24/03/2014	4,700	5,704	10,855	16,559
25/03/2014	5,322	9,427	11,881	21,308
26/03/2014	4,956	4,805	8,651	13,456
27/03/2014	5,091	6,700	10,602	17,303
28/03/2014	4,512	3,651	12,924	16,575
31/03/2014	4,717	9,103	8,088	17,191
01/04/2014	4,505	8,609	9,444	18,052
02/04/2014	4,935	10,346	10,426	20,772
03/04/2014	5,057	10,413	10,577	20,991
04/04/2014	5,565	6,049	12,168	18,217
07/04/2014	5,576	10,372	12,312	22,684
08/04/2014	5,263	11,008	11,050	22,059
09/04/2014	5,620	7,376	12,741	20,117
10/04/2014	5,918	6,126	8,720	14,846

The quantitative data that was obtained from the empirical research phase has been analyzed and summarized into a tabular format, in which from above tables, not only blood that was collected in large quantity, but also other organs, such as, hair, lard, and liver as well. However, the aim of this research is to valorize porcine blood so that the others are excluded from further investigation in this report.

The total data of 71 days was pooled out for analysis the pattern of blood collection, and the total figures of blood are interpret into Figure 16 while the total ratios of 71 days are displayed in Figure 17 below.

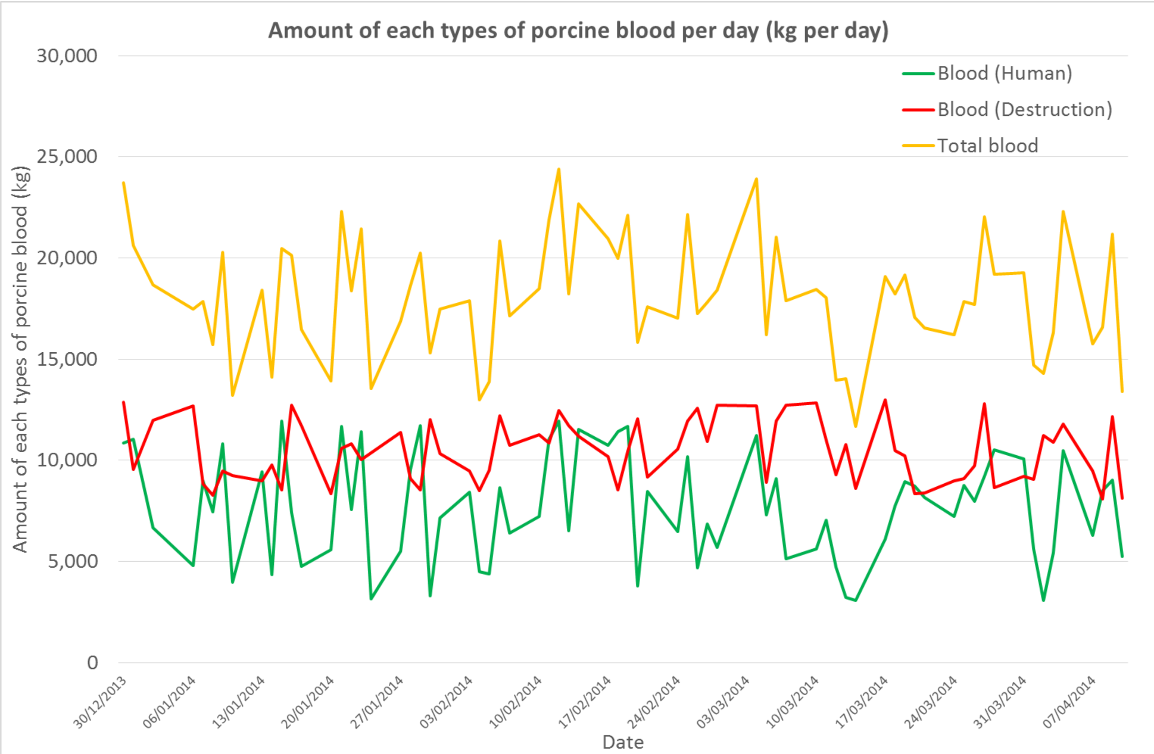

Figure 16: Amount of each types of porcine blood per day

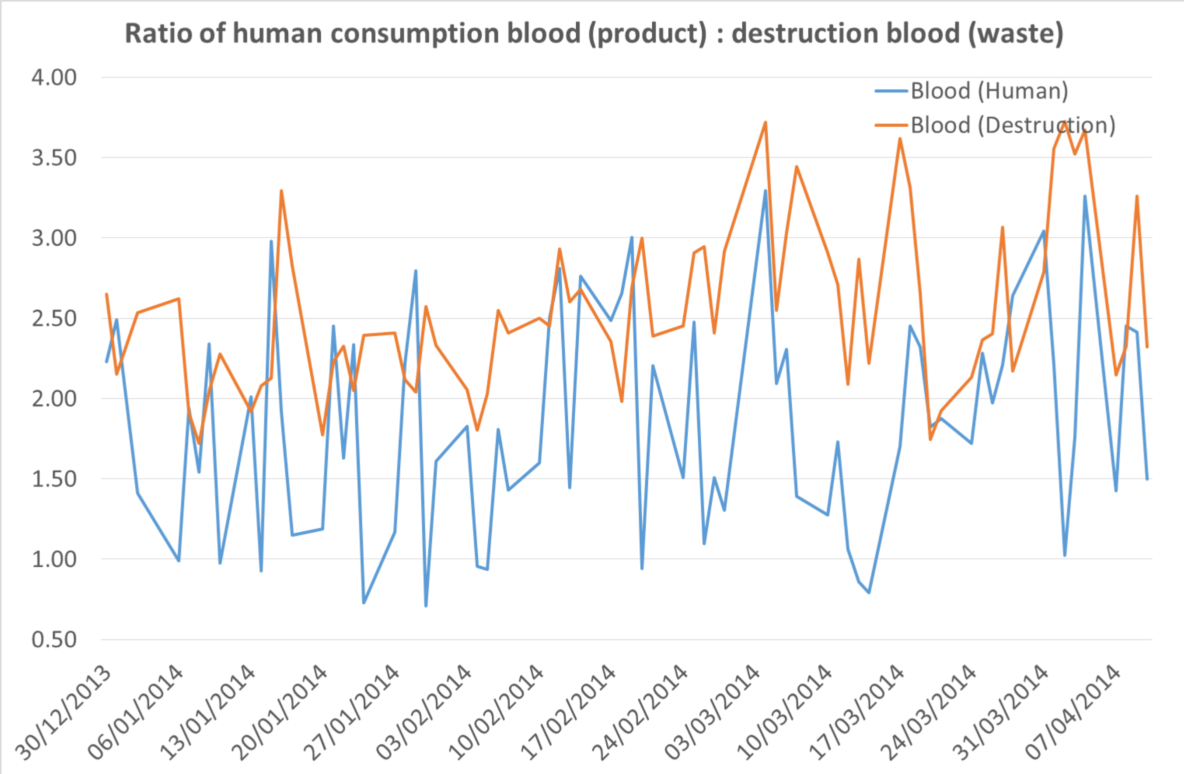

Figure 17: Ratio of human consumption blood (product): destruction blood (waste)

The average figures of human consumption blood, destruction blood, and total blood are 8,800, 11,400, and 20,300 kg per day, which can be further interpret into an average ratio of human consumption blood (product)/destruction blood (waste) as 2.13: 2.75. From the graphs, it is clearly seen that porcine blood does not generate a reasonable income because the number of waste is bigger than the number of product and the company outsources Rendac Company to dispose of the waste blood, which result in deficit around -200 €/day. Each of presented technologies was put into comparison at the end of this chapter for the company to decide at a later stage. Without any blood valorization, this problem will be getting worse in the next fifteen years, especially, with a new slaughterhouse, because it is planned to have an average slaughtering capacity of 6,931 pigs/day. With this larger number of pigs, the deficit on blood is expected to raise to -410 €/day when considering only porcine blood.

4.2 Technological and Legal aspects

This section includes an analysis of presented technologies and relevant legislation along with company requirements. This analysis uses two influential factors from the PESTEL framework to determine feasible technologies by using company requirements and regulations as a filter.

The list of presented technologies from subsection 2.2.4 is the Anitec hollow knife, an evaporator, a centrifuge, blood meal production equipment, a spray dryer, protein isolation equipment, and bioactive peptides production equipment. In total seven technologies are presented in this report. The company representative set a few conditions for selecting valorization technologies; first, valorized products must be sold to other firms; second, valorized products must not be in the energy sector according to Figure 9; lastly, valorized products should generate the greatest economic benefit for the company. In this research, the researcher took the requirements of the company as first priority criteria to discuss with them. The company chose the first five technologies. These are the Anitec hollow knife, an evaporator, a centrifuge, blood meal production equipment, and a spray dryer.

According to the legal aspects in subsection 2.2.6, all of these five technologies comply with EU laws and regulations. For better understanding, the researcher divided the effective EU legislations into three groups: machines, processes, and products. Since the company planned to outsource engineering companies to help them in implementing new equipment for a new slaughterhouse; thus, suppliers are responsible persons. Regarding to discussions of the researcher and potential suppliers, they stated and confirmed that their equipment complies with both EU and US laws and regulations; thus, the machine group passed the requirement. Processes of production always come together with equipment. Since the machines comply with legislations, it can be assumed that processes also comply with EU law and regulations; unless the company made modifications to the process. Apropos to the economic aspect in subsection 2.2.2, both human foodstuff and animal feed markets are large and have continuous growth rate; thus, valorized products as foodstuff are intended for human consumption and animal feed are in the scope of 'product' legislations.

Before valorizing porcine blood becomes finished goods, it must comply with EU legislations as a fundamental requirement. Because blood obtained from the Anitec hollow knife complies with EU regulations as both food and feed materials so the company decided to implement it in their new plant. Valorized porcine blood as human foodstuff that the five technologies can produce are fresh porcine blood, RBC, plasma, concentrated RBC, concentrated plasma, spray dried RBC, and spray dried plasma. These products are suitable for human consumption if they are processed with appropriate equipment and processes, and products must comply with 'hygiene package' and GFLR regulations (see subsection 2.2.6). Similar to for human consumption porcine blood must be processed with hygienic equipment and suitable processes, and take product specification requirements into account. From the five technologies, animal feed that complies with legislations are blood meal, spray dried blood powder, spray dried RBC, and spray dried plasma.

Technologies that can be used for valorization porcine blood into either human foodstuff or animal feed products after screening by company requirements and legal aspects are the Anitec hollow knife, an evaporator, a centrifuge, a steam coagulator, a disc dryer, and a spray dryer.

4.3 Technological and economical aspects

This section reveals costs and benefits of the seven equipment, and applies this information into a TOWS matrix to analyze economic potential of each technology. The objective of this section is to find suitable valorization technologies for the company and compare economic potential of presented technologies and the currently use method of the slaughterhouse. Costs and benefits of each technology are calculated by using cost accounting theories in subsection 2.2.2, and the greatest benefit technology is analyzed by SWOT analysis theory from section 2.4.

Costs of cleaning agents, middle-level educated employees (in Dutch: MBO), energy, and maintenance are 5 €/day/machine, 33 €/hour, 225 €/ton of evaporated water, and 8% of equipment cost per year, respectively. However, employee cost is shared among several equipment, because equipment does not require employee to station with them all the time.

4.3.1 Anitec hollow knife

The hollow knife system is a semi-automatic system, so it requires only one employee to operate the machine (see part 2.2.4.1). The Butina Company suggested that the new pig slaughterhouse should use their 'RotaStick 14' for the blood collection process. A sales person quoted the price of this machine at €770,000, but did not provide any other information such as maintenance and service costs. In addition, he suggested the amount of blood that could drain per pig is 3.15 kg, which conflicts with the figure this researcher had calculated. From the results, the researcher found that the average total blood per pig from the slaughterhouse is around 4.88 kg per animal or 3.83% of live weight (see Figure 18). The hollow knife machine is capable of draining around 85% of the total blood, which is 4.15 kg/pig, and the remaining 15% is destruction blood. Thereby, the total amount of blood for production per day is calculated from 6,931 pigs multiplied by 4.15 kg, equals 27,312 kg, and 4,745 kg as destruction blood. However, the data conflicts with calculations from equations in Figure 19 (less than the previous one), in which 29,099 kg is the total amount of blood. According to information from the company, the current price of human consumption blood is 40 €/ton that is 899 €/day. The researcher chose the answer obtained from Figure 18 as a reference number because data from Figure 19 was calculated from an amount of slaughtered pigs and the total amount of blood, but did not consider live weight of pigs. On the other hand, Figure 18 used an average live weight for calculation so that the data are more reliable. Additionally, the anticoagulant, sodium citrate, is often used to prevent blood clots; the practical ratio of anticoagulant (3.8%) to fresh blood is 1:9 (see section 2.1). Hence, the estimated usage amount of anticoagulant is around 100 kg per day. Price of sodium citrate is in the range of €557 to €14,000 per metric ton so that the total cost of anticoagulant is €56 to €1,400 per day (Anon 2014g, Anon 2014m, Anon 2014l, Anon 2014b, Anon 2014s, Anon 2014q, Anon 2014r, Anon 2014f, Anon 2014t, Anon 2014a, Anon 2014j, Anon 2014p). The slaughterhouse, however, does not pay for the citrate by themselves, but the SONAC B.V. supplies the chemical for them; thus, we do not have a reference price for the citrate. The researcher, however, contacted his confidential source for the price of citrate, and it was estimated to be around 600 €/ton, which close to the minimum price, so the minimum price of 557 €/ton was used for estimated the valorization cost.

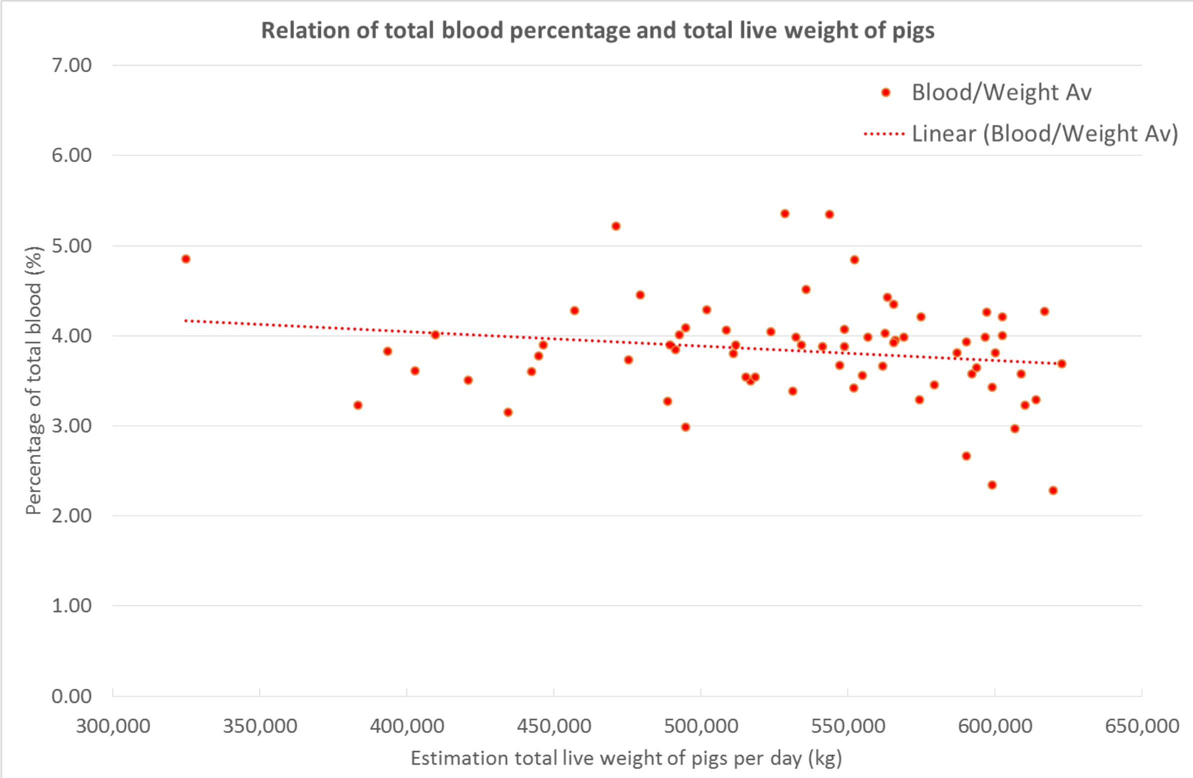

Figure 18: Estimation of total blood that can drain from live pigs

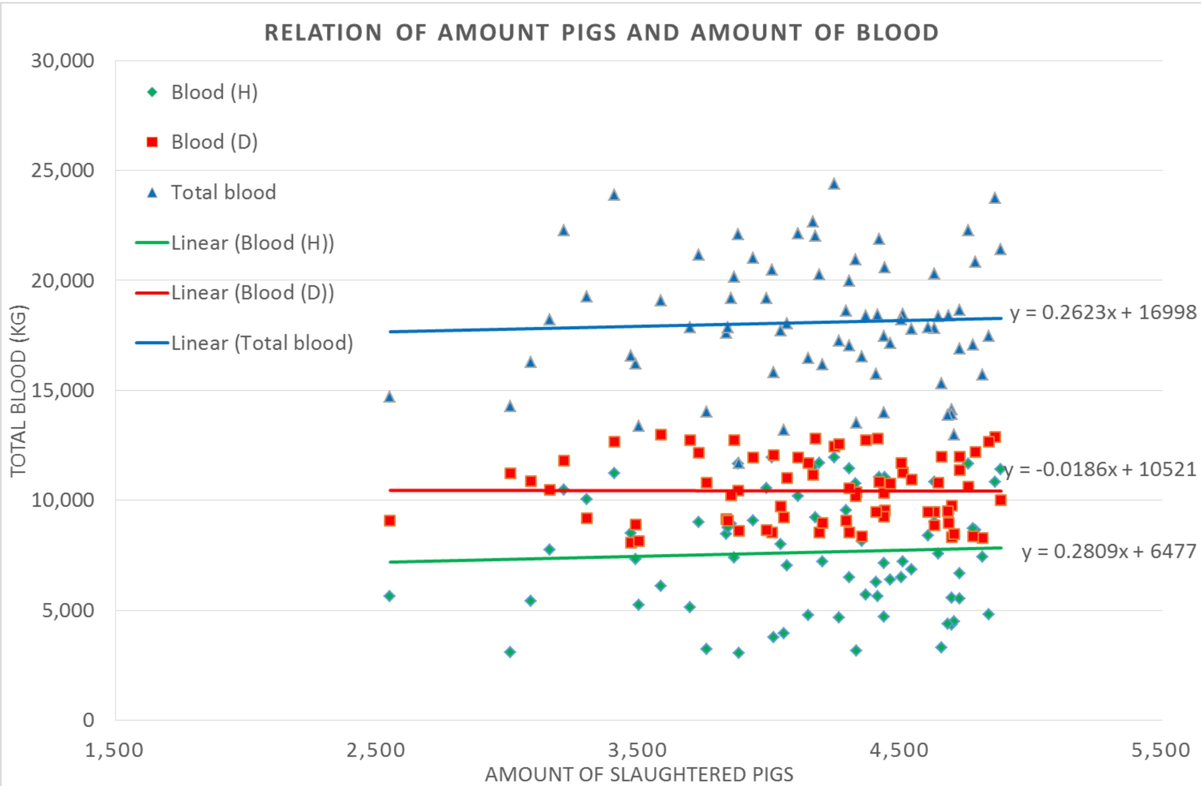

Figure 19: Estimation of porcine blood calculated from the amount of slaughtered pigs

Additional to the chemical, the energy cost of heating water to disinfect knives should be incorporate in the cost of this equipment as well. The slaughterhouse, currently, uses natural gas as their source of energy to generate heat. According to the responsible person from the slaughterhouse, the updated price of natural gas obtained from database in 2013 is 0.366 €/m^3. The estimated amount of water used is 1.8 liters/pig, which was gained from sales person of Butina Company. Therefore, the total amount of water used per day from Anitec hollow knife in the new slaughterhouse will be 11,664 liters/day. Generally, water has gradient temperature around 25°C, so this number is used for calculate the energy consumption, and the cost of heating water for the hollow knife is estimated to be around 57.24 €/day.

4.3.2 Centrifuge

A centrifuge is an automatic machine that requires an employee to check on the ratio of RBC and plasma from time to time. Both GEA Niro and Butina quoted the price of their machines at €300,000 and €308,000, respectively. Apart from the price of the machine, the sales person of Butina Company did not provide sufficient information about it, so that it was excluded from further investigation in this project. The centrifuge separates porcine blood into RBC and plasma at a ratio of 40:60 (see section 2.1). When calculating the previous estimation amount of blood with this ratio, weights of RBC and plasma are 10,790 and 16,185 kg per day respectively.

4.3.3 Membrane filtration

An Ultrafiltration (UF) is an optional, widely used piece of equipment in industry scale to reduce moisture content from RBC and plasma. Some companies also use a Reverse Osmosis filtration (ROF). ROF has a better capability of filtration than an UF, but the total costs of the machine and apparatus are more expensive than an UF, such as filter costs and maintenance costs. According to the meeting between the researcher and GEA Niro staff, the price of an UF machine is estimated to be around €300,000 while the cost of a ROF is not yet revealed. The lifetime of UF from GEA Niro is up to 40 years with regular maintenance. Concentrated hemoglobin, concentrated plasma proteins, and discharged water are outputs and by-products of this process. Ideal concentrations of total solid from hemoglobin and plasma are 15 – 20%. Additionally, an evaporator can be employed together with UF to reduce the working load of a spray dryer.

4.3.4 Evaporator

Similar to a membrane filtration, an evaporator is optional equipment for the slaughterhouse to implement into their system. Reducing water content and pre-heating blood constituents are the main tasks of an evaporator. It consumes energy to generate heat for water evaporation, but the excess heat can be recovered using heat exchanger equipment. Consequently, outputs from this machine are concentrated RBC, concentrated plasma protein, water (condensate), and excess heat. Ideal concentrations of RBC and plasma protein are 40 – 55% total solid. The GEA Niro quoted €650,000 for their evaporator and a lifetime up to 40 years with consistent maintenance. Unlike a membrane filtration, the evaporator is a solitary machine that does not need an UF to work with. Furthermore, the evaporator has benefits over an UF in terms of lower water content in output and higher temperature of blood components. Because of these advantages, the company can install a smaller spray dryer which is more cost efficient than a large one.

4.3.5 Blood meal production

Generally, blood goes through a steam coagulator to clot it before sending it to a disc dryer. Clotted blood is not only easy to process into powder, but also increases the concentration of constituents because water is squeezed out. A disc dryer is employed for producing blood meal using concentrated hemoglobin or RBC as substrates. Outputs of this machine are blood meal powder and water (condensate). A desired characteristic of blood meal is 92% total solid (i.e. protein, minerals, and elements) with 8% moisture content. If feed material contains a moisture content of over 8%, the company must declare it when registering the product (see sub subsection 2.2.6.2). In order to reduce water content to 8% or less, the machine uses a substantial amount of energy to evaporate moisture from blood meal. Blood meal produced through these processes is not suitable for human consumption because the equipment is not certified for foodstuff. Current prices of blood meal in markets are in the range of 147 – 752 €/ton (Anon 2014c, Anon 2014e, Anon 2014d, Anon 2014v, Anon 2014i, Anon 2014u, University of Missouri Extension 2014). The company should consider the water content of inputs because energy used at this stage cannot be recovered, thus it has cost implications. At least one employee is required for this process while prices of a steam coagulator and a disc dryer are approximately €300,000 and €625,000, respectively. Even though, the researcher received a quotation from GEA salesperson, but installation of this equipment will be done via another company, not by the GEA Group itself.

4.3.6 Spray dryer

A spray dryer is essential in producing plasma powder. Possible substrates for the machine are concentrated blood, concentrated hemoglobin, concentrated plasma, and isolated plasma proteins. Blood powder, Hemoglobin powder, plasma powder, and isolated plasma proteins are products that this machine can generate from porcine blood. Similar to a disc dryer, it consumes a high amount of energy and it is unrecoverable. Not only the energy consumption is of concern, but also size and capacity of the machine are significant. Price of equipment that has a 400 kg tank size and 1,000 kg are €900,000 and €1,500,000, respectively. The researcher managed to obtain selling prices from various countries (not one of them is from the Netherlands) of hemoglobin powder and plasma powder are 280 €/ton (Anon 2014w) and 945 – 3,780 €/ton (Anon 2014n, Anon 2014o, Anon 2014k, Anon 2014h), but regarding to meeting with sales person from GEA Niro, they found that prices of these products from trade companies in the Netherlands in 2014 are 1,000 €/ton and 5,500 €/ton, respectively. Because of this research is based on the ABC slaughterhouse, which locates in the Netherlands, so the researcher used the data from the GEA sales person as a reference.

4.3.7 Isolated plasma protein production

There are several companies, who commercialize their plasma protein products, but the expertise and technology are kept secret within firms. Regarding discussions with the company representative, he was not interested in these products due to the very high technology involved, which is not suitable for the company that enters new markets. Therefore, the researcher did not investigate costs and benefits of this equipment.

4.3.8 Bioactive peptides production

Among proposed valorization technologies, bioactive peptides production is the most advanced technology because the company does not have any expertise in enzymology. According to the company representative, this valorization technology is too complex for the company at this moment; thus, the researcher did not study costs and benefits of this process.

4.4 Summary

This section summarized investment costs and selling costs of feasible valorization technologies. The proposed technologies are grouped into five schemes to find which scheme has the highest economic potential, and the winner is analyzed by the SWOT analysis and PESTEL's framework for the suitable business strategies in different circumstances.

Summary of cost
Information obtained from the empirical research phase and suppliers are used for constructing a summary table of available costs as in Table 10.

Table 10: Summary of cost from several valorization equipment

<table>
<tr><th>Machine</th><th>Cost</th><th>Chemical</th><th>Employee</th><th>Maintenance</th></tr>
<tr><td>Anitec hollow knife</td><td>€770,000</td><td>Anticoagulant
56 – 1,400 €/day</td><td>1 person</td><td rowspan="10">8% of machine cost per year</td></tr>
<tr><td>Centrifuge</td><td>€300,000</td><td rowspan="6">Cleaning agents
5 €/day/machine</td><td rowspan="6">1-3 persons
33 €/hour</td></tr>
<tr><td>Membrane filtration</td><td>€300,000</td></tr>
<tr><td>Evaporator</td><td>€650,000</td></tr>
<tr><td>Steam coagulator</td><td>€300,000</td></tr>
<tr><td>Disc dryer</td><td>€625,000</td></tr>
<tr><td>Spray dryer</td><td>€900,000 or
€1,500,000</td></tr>
<tr><td>Isolated plasma proteins equipment</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Bioactive peptide equipment</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Summary of income
Data of prices and markets of products are summarized in
Table 11. According to one supplier, prices of hemoglobin powder and plasma powder in the Netherlands are 1,000 €/ton and 5,500 €/ton, which have higher values than other sources.

Table 11: Summary of income from feasible products from valorization technologies

Products	Price	Market	Remark
Fresh blood	40 €/ton	Any	-

RBC	-	Any	No price data
Plasma	-	Any	No price data
Blood meal	147 – 752 €/ton	Animal feed	Can sell as fertilizer
Hemoglobin powder	1,000 €/ton	Human foodstuff	280 €/ton (China)
Plasma powder	5,500 €/ton	Human foodstuff	945 – 3,780 €/ton (China & USA)
Plasma proteins	N/A	Any	-
Bioactive peptides	N/A	Medicinal compounds or human foodstuff	-

Not any of single equipment can produce products by itself, and to find the highest economic potential technology for the company, the researcher grouped the equipment into five schemes based on the feasible valorized products:

1. Fresh porcine blood: Anitec hollow knife
2. Blood meal: A steam coagulator + a disc dryer
3. Hemoglobin powder and plasma powder: Anitec hollow knife + a centrifuge + an evaporator + two small spray dryers (capacity 400 kg)
4. Hemoglobin powder and plasma powder: Anitec hollow knife + a centrifuge + a membrane filtration + two large spray dryers (capacity 1,000 kg)
5. Blood meal and plasma powder: Anitec hollow knife + a centrifuge + an evaporator + a small spray dryer (capacity 400 kg) + a steam coagulator + a disc dryer

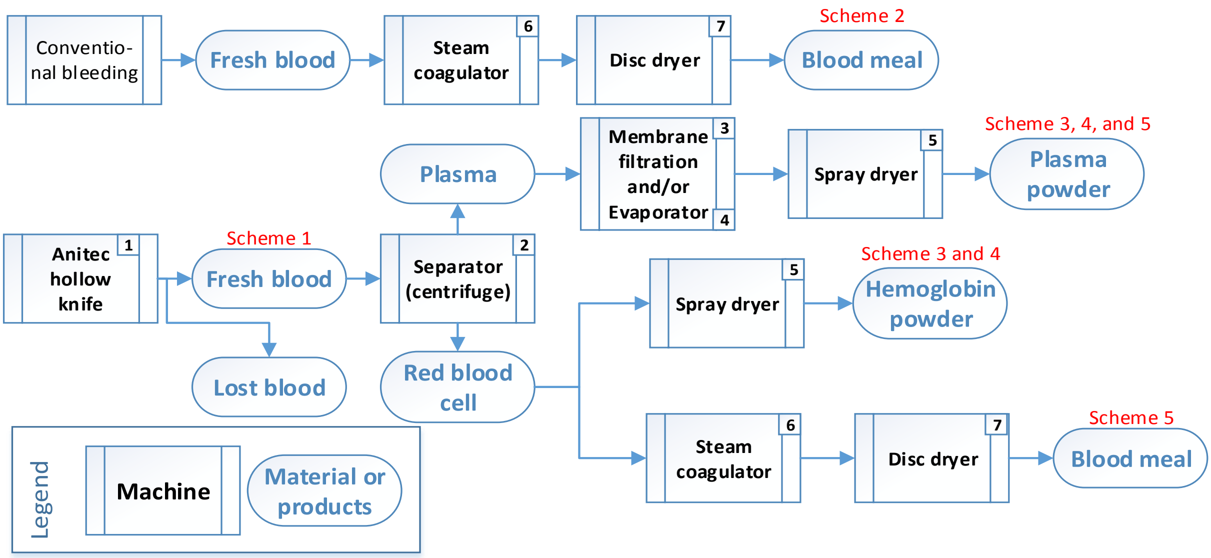

Figure 20: Five schemes valorization scenario with main equipment

The total estimated amount of porcine blood obtained from the bleeding process of the new slaughterhouse is 33,982 kg/day (see subsection 2.2.2). It can be further divided into human consumption (85%) and undrainable blood due to machine capability (15%), in which the latter is lost during the slaughtering process. If the company valorizes whole blood into blood meal, they do not need hollow knife equipment and can valorize whole blood into the product at a rate of 5,710 kg per day. As for the third, the fourth, and the fifth schemes, the major portion of 85% is centrifuged to plasma (60%) and RBC (40%). At the end of the valorization line, spray dried hemoglobin (3,888 kg per day) and spray dried plasma (1,325 kg per day) are products for the third and the fourth schemes. The fifth scheme is a combination of spray dryer for plasma powder (1,325 kg per day) and a disc dryer for blood meal (3,888 kg per day). It is important to note that only the second scheme can valorize all of estimated blood without any loss because of the conventional bleeding method and the product is not feed. The five schemes valorization scenario of products and machinery are illustrated in **Error! Reference source not found.** and Figure 20, correspondingly. The percentage in **Error! Reference source not found.** displays ratio of separation while the number in the boxes display the amount in kg unit of raw material and/or valorized products at each stage of the production of five schemes. Figure 20 illustrates the required equipment for each scheme, processes of five schemes, and the valorized products of each scheme. The number (1 – 7) at the top right corner in the boxes indicates the proposed seven technologies that need to be implemented in each scheme.

All of the necessary costs and benefits were gathered according to subsection 2.2.2, there are three types of cost behavior: fixed costs, variable costs, and semi-variable costs. In this project, fixed costs are machine costs; variable costs are chemical agents cost and labor costs; lastly, semi-variable costs are maintenance costs and energy costs. Revenues are from the selling price of valorized products from five schemes. When combining estimated data of costs and benefits, the economic potential of each scheme will be revealed by the value of return on investment (ROI)—the higher the value, the better the economic potential. Break-even point (BEP) can revealed the amount of time, usually in year basis, that investment of a project equals revenue from the project, the shorter of BEP, the better economic potential for the company. ROI formula and BEP formula that were used in the calculations are:

$$Break\ even\ point\ (BEP) = \frac{Fixed\ costs}{Selling\ price - (Variable\ costs + Semivariable\ costs)}$$

$$\text{Return on investment (ROI)} = \frac{(\text{Annual gains from investments} - \text{Annual investment costs})}{\text{Annual investment costs}} \text{ x } 100$$

Comparisons of five schemes in terms of costs and benefits are displayed in Table 12. All of the BEP and ROI calculation can be found in appendix.

Table 12: Summary of available costs and benefits for five valorization schemes

	1	2	3	4	5
Expense					
Hollow knife machine 770,000 €/machine	1 machine		1 machine	1 machine	1 machine
Anticoagulant 56 – 1,400 €/day	Yes	Yes	Yes	Yes	Yes

Centrifuge 300,000 €/machine			1 machine	1 machine	1 machine
Membrane filtration (UF) 300,000 €/machine			1 machine		
Evaporator 650,000 €/machine				1 machine	1 machine
Steam coagulator 300,000 €/machine		1 machine			1 machine
Disc dryer 625,000 €/machine		1 machine			1 machine
Spray dryer (small) 900,000 €/machine			2 machines		1 machine
Spray dryer (large) 1,500,000 €/machine				2 machines	
Employee 33 €/hour	1 person	2 persons	2 persons	2 persons	3 persons
Extra cleaning hour 33 €/hour	1 hour/day	1 hour/day	1 hour/day	1 hour/day	1 hour/day
Cleaning agents 5 €/day/machine	1 machine	2 machines	7 machines	7 machines	6 machines
Energy cost €/day	57.24	1,899	3,286	1,927	1,522
Maintenance cost 8% of equipment cost	€61,600	€74,000	€349,920	€333,920	€283,920
Income					
Fresh blood 40 €/ton	27.345 ton				
Blood meal 147 – 752 €/ton		5.989 ton			3.888 ton
Hemoglobin powder 1,000 €/ton			3.888 ton	3.888 ton	
Plasma powder 5,500 €/ton			1.313 ton	1.313 ton	1.313 ton
Summary					
Revenue (€/day)	899	909 – 4,494	11,200	11,200	7,888 – 9,999
Raw material cost (€/day)		899	899	899	899

Equipment cost (€)	770,000	925,000	4,374,000	3,524,000	3,549,000
Depreciation cost (€/year)	51,333	61,667	291,600	278,267	236,600
Maintenance (€/year)	61,600	74,000	349,920	281,920	283,920
Energy cost (€/day)	57.24	1,899	3,286	1,927	1,522
Labor cost (€/day)	238	414	414	414	613
Chemical cost (€/day)	61	66	81	81	86
BEP (years)	7.11	2.77[1]	2.31	1.55	1.61 – 2.66
ROI (%)	3.41	17.12[1]	53.10	107.33	50.11 – 96.13

Due to limits of time and accessibility to confidential data sources from suppliers, only available costs are calculated to determine economic potential of the five schemes.

Table 12 shows that the first scheme has the longest BEP of 7.11 calendar years. The second scheme is risky because it could have the shortest BEP of 2.77 years, but it could also result in net loss. The third scheme requires 2.31 years before it will reach BEP. The fourth scheme has the shortest BEP of 1.55 years. The fifth scheme takes 1.61 – 2.66 years for its BEP. When considering BEP as a main criterion, only the second scheme, the fourth scheme, and the fifth scheme are looking favorable, but if the slaughterhouse takes income of each scheme into account, the fourth scheme has the highest economic potential, because of the greatest expected revenues of 11,200 €/day. Using ROI as a criterion, both the fourth scheme and the fifth scheme look promising because of the highest and the second highest ROI than the rest, respectively; however, the fifth scheme has a fluctuation in ROI, but the fourth scheme does not have. Therefore, the fourth scheme seems the most promising valorization method for the new slaughterhouse.

Analysis of scheme IV by a SWOT analysis and Porter’s framework
Since scheme IV is the most interesting valorization investment, because of the highest ROI and the lowest in BEP, so it was analyzed using a SWOT analysis technique combining with Porter’s framework to produce reliable strategies for possible various circumstances. A list of possible strategies obtained from the SWOT analysis for the company to operate is displayed in Table 14. The SWOT analysis strategies are discussed in following paragraphs.

Strength-Opportunities (S-O) strategy
The strength of the company is the capability of producing porcine blood as raw material for valorization by themselves, while opportunities are consistent target markets growth rate and synergy of the Byblos project members (The Byblos project is a co-operation among business partners of the ABC slaughterhouse). Other possible strategy that can be deduced from strengths and opportunities are outsourcing other firms in the Byblos project, such as, AAA, producing valorized products for the slaughterhouse or selling fresh or partial valorized porcine blood to Byblos members.

According to Porter’s framework, if the company tries to get into new market, they need to strive through several entry barriers, for example, retaliation from the incumbents (current market shareowners); however, with the proposed solutions, the slaughterhouse is less likely to receive retaliation from the incumbents, because the slaughterhouse has several business collaborates in the Byblos project, thus it is feasible to start the valorization project. Nevertheless, the slaughterhouse needs to cope with threat of new entrants (moderate level), threat from buyer (moderate level) and threat from incumbents (low level). The moderate to high level of threat of new entrants is due to there are many companies that capable of producing valorized porcine blood in the world. Even though, there are 11 pig slaughterhouses in the Netherlands (CBS 2013), but there are many trading companies that can import products from other continents that are cheaper than the products produced in the Netherlands because of the lower in the cost of living. Thus, it is important for the company to take into account of several threats from the proposed strategies.

Strength-Threats (S-T) strategy
Threats for valorized products are disease or outbreaks and incumbents from blood industry, while strength of the company lies within their own resource. As with the recently circumstance of virus outbreak in swine, the company must act and improve their procedure according to EU laws and regulations in order to prevent their products from disease — Swine Delta Corona virus (SDCV) currently outbreaks in Asia and North America. However, the cost of implement the new EU procedure into the new slaughterhouse is not a large investment, so it is not a serious threat to the firm. Yet again, threats from other companies from blood industry in term of product substitution and price cut are still exist. Once again, to collaborate with the incumbents from the target market or Byblos project will help the company to achieve their target in expanding valorized products in an interested market. Another possible solution for the slaughterhouse to deal with threats from other companies is to set up R&D team or collaborate with research institute to develop potential products and sustainable process.

From the SWOT analysis above, the threat that can be solved easily is the SDCV; however, there might have new swine diseases in the next fifteen years, but EU had announced the procedure of dealing with SDCV, so it is not of concern for this option. On the other hands, the slaughterhouse could get retaliation from incumbents, for example, Sonac B.V., if the slaughterhouse entered new markets as a competitor. To co-operate with incumbents by selling fresh or partial valorized porcine blood to them as a supplier could solve the retaliation problem but this is not generate much value compare to now. If the company plans to set up their own R&D team to earn more profit, they should carefully consider about investment, because this asset can end up to be their exit barrier regarding to Porter’s framework. If the company decides to cooperate with research institute, they can prevent the entry/exit barrier threat.

Additionally, the recent incident between Ukraine and Russia has a large impact on the ABC slaughterhouse because Russia, which is a potential customer, stopped importing goods from EU resulting in a massive amount of stocked pig meat. As of before the crisis, only uncooked meat products from the slaughterhouse were sold to Russia, but not including porcine blood; thus, this incident is indirectly related to the current business case of valorized blood products because of differences in customer groups (i.e. consumer, trade company, and food industry). Nonetheless, the company might short in the investment for the new slaughterhouse unless they can sell their stocked meat. The recommended solution for this situation is to export the stocked products to Greece, Poland, and United Kingdom, because they have steady growth rate in the volume of imported pig meat from the Netherlands since 2000. Moreover, the company could also export to Italy, Germany, and France, because they are also in the top six of pig meat importers of the Netherlands (CBS 2013). Even though, other countries have the largest share of Dutch pork export, there is no solid information about the size of market share per countries and their locations. Furthermore, the top six of Dutch pork importers are located in Europe; thereby it is more interesting for the company to expand their territory to these countries.

Table 13: Destination of Dutch pig sector's exports in 2000-2012 of pig meat (excluding (cooked/canned) meat products and bacon), weight including bones

Year / Sell to country %	2000	2005	2010	2011	2012
Italy	22.8	24.1	18.8	17.9	19.2
Germany	26.3	21.3	21.2	16.3	17.4
Greece	8.9	12.6	11.4	12.5	12.6
United Kingdom	6.8	10.8	11.6	10.6	11.1
Poland	0.0	2.7	4.1	8.2	10.0
France	9.8	4.9	3.7	2.4	1.9
Russia	2.9	2.7	3.1	3.9	0.9
Other countries	22.5	20.9	26.1	28.2	26.9

Weaknesses-Opportunities (W-O) strategy

No research and development (R&D) team for new products and lack of experience with advanced valorization technologies are weaknesses of the slaughterhouse. In order to achieving the valorization project, the company needs to adapt their weaknesses into strengths. Hiring R&D staff and building their own laboratory to develop their own unique product with patents is a long-term solution, and if the company co-operate in developing new products with other firms, this helps in achieving the valorized project. However, the estimated costs of building a new lab can be from €500,000 to €1,000,000 or more, which is a large amount of investment that the company need to consider (Veronese 2011).

The large investment is one of the entry/exit barrier according to Porter's framework, and the investment will turn into an exit barrier when the company wants to leave the market; thus, the company should carefully consider and analyze the possibilities. The solution of building their own R&D team or joining forces with research organization will make the company moving to S-O or S-T strategy depending on an upcoming situation.

Weaknesses-Threats (W-T) strategy

This is the worst situation for the slaughterhouse, and two options are available. First, the company must overcome their weaknesses by turning them into strengths (moving toward new S-T). Since the company has their own R&D team, they are capable of developing new products that will have no effects from the disease. However, retaliation from incumbents remains, so R&D team should develop or invent new products that can exploit a new market. Second option, which is not recommended to do, is to cancel the blood valorization project.

This is the worst situation analyzed by a SWOT analysis, and all of possible threats from Porter's framework will accumulate in this possibility. If the company fell into this circumstance, they need to struggle to move themselves to S-T strategy. This is a fight or flight situation for the company, if the company choose to fight, they need to invest a large sum of money to and put loads of effort in set up a R&D team and develop favorable potential products to sell in a market. Even though, the company makes a decision of going through this sort of processes, there is no guarantee that the firm will strive through this situation. Conversely, if the company choose to flight or back out from this market, it is safe to do so, because the firm does not invest much in this field yet; thus it is easy to change the interested market to another favorable one.

Table 14: A SWOT analysis of scheme IV valorization method

	Opportunities: **1**. Growing market demands **2**. Synergy within Byblos project	**Threats:** **1**. Disease or outbreaks **2**. Competitor from Incumbents of blood products
Strengths: **1**. Own resources	**S-O**: **1**. Outsourcing other firms in Byblos project to produce products **2**. Selling raw material to other firms in Byblos project	**S-T**: **1**. Using more stringent methods for monitoring disease **2**. Co-operate with an incumbent by being their supplier
Weaknesses: **1**. No experience with advanced valorization technologies **2**. No R&D team	**W-O**: **1**. Hiring a R&D officer and manager with experience in valorization technologies **2**. Co-operation and sharing information between members of Byblos project	**W-T**: **A**. Overcome weaknesses by making them strengths (moving to S-T) **1**. Develop products that have no effect from disease **2**. Develop novel products that can open a new market **B**. Possible option not recommended for the firm **1**. Cancel this project

Other possible outcomes

Since the new slaughterhouse will be finished in the next 5 years, so the situation of price of valorized products might have changed; thus, to mitigate the error of estimated selling price, it is good to assume that the price will fluctuate by ± 10% of current finding prices. The fluctuated prices will affect both the BEP and ROI of every scheme, and will increase or decrease the economic potential of them. Nevertheless, to see the changes that affect every scheme will give insight to the company when they are making a decision of valorization project. The results of price fluctuation are displayed in Table 15.

Table 15: Effect of ±10 percentage of price fluctuation on BEP and ROI of five valorization schemes

BEP	1	2	3	4	5
Income -10%	9.77 years	-0.98 years[2]	2.91 years	1.77 years	3.31 years
Income +10%	5.70 years	0.60 years[1]	1.91 years	1.31 years	1.45 years
ROI					
Income -10%	-6.97%[2]	-79.47%[2]	37.77%	86.01%	35.21%
Income +10%	13.87%	29.13%[1]	68.99%	127.55%	114.02%

From the above table, scheme IV is the most promising scheme, because it has the shortest BEP and the highest ROI compare to others. If the selling price decreases by 10%, the BEP and the ROI will be 1.77 years and 86.01%, respectively. The possible causes of this reduction in selling price might due to the spreading of the SDCV, the shrinking of market, or the increasing number of new entrants (suppliers) leading to price cut.

Conversely, if the price increases by 10%, both the BEP and the ROI will be 1.31 years and 127.55%, respectively. The economic potential of the scheme IV is getting higher due to the increasing of ROI and decreasing of BEP. The possible explanations of these circumstances are the growing in demand for valorized porcine blood or competitors move their products to new markets, or the current suppliers stop supplying to the market.

[2] Most likely will result in deficit since it has negative values

5. Conclusion and discussion

The final chapter of this report consists of two sections: conclusion and discussion.

5.1 Conclusion

This section aims to answer the central research question:

“What is the most suitable valorization method for porcine blood from the ABC slaughterhouse in terms of technological feasibility, local and international economic potential, and the recently changed EU regulations?”

To answer the central research question, sub research questions were formulated to help in answer the main question, discussed in subsection 5.1.1, 5.1.2, and 5.1.3. The central research question will be answered in subsection 5.1.4.

5.1.1 Technological feasibility of valorization methods

This subsection aims to answer the following sub research question:

What criteria are of use to analyze the technological feasibility of valorization methods of porcine blood from the ABC slaughterhouse?

a) What are the attributes of porcine blood from the ABC slaughterhouse?
b) What are the suitable valorization technologies for porcine blood from the ABC slaughterhouse?
c) Who are the suitable suppliers, according to the chosen valorization method?

The literature study and empirical research aimed to seek for technological feasibility of valorization technology by applying criteria. First, the attributes of porcine blood, suitable valorization technologies, and suitable suppliers are revealed.

Attributes of porcine blood
Attributes of porcine blood can be obtained from the literature study and empirical research. Literature described chemical, biological, and physical properties of blood while field research revealed amounts, history, and bleeding technique of the ABC slaughterhouse. This is essential information for choosing feasible valorization technologies.

There are conflicts in some of the collected information, but the researcher used the data from empirical research as a main source because this is a practical research project. So, attributes of porcine blood can be found in section 2.1 and this research concluded that blood from 6,931 pigs equals to 33,982 kg, which can be further declared as 60% plasma (8% protein content) and 40% red blood cells (RBC) (35% protein content).

Suitable valorization technologies
The researcher used attributes of porcine blood as criteria to search for suitable valorization methods from the literature study. In addition, the value pyramid and specific conditions from the company demarcated feasible valorizations, so that out of seven methods, only five valorization technologies are put forward. To mix and match five technologies together, five valorization schemes were created for assessing economic potential.

This research concluded that five valorization technologies are suitable for the ABC slaughterhouse at this moment. These are Anitec hollow knife, a separator (a centrifuge), a concentrator (membrane filtration and an evaporator), blood meal production (a steam coagulator and a disc dryer), and a spray dryer.

Suitable suppliers
Conditions that the company required of suitable suppliers for valorization technologies are; providing after sales service, have a good reputation, and are reliable. In addition, suppliers must be able to support implementing five feasible technologies in the new slaughterhouse. From these requirements, there are three suppliers indicated, they are Butina Company, GEA Group, and I.C.F. & Welko Company. However, only Butina Company and GEA Group were successfully contacted and exchanged information with the researcher. Therefore, most of the machines and information were from these two sources.

Criteria for analyzing technological feasibility of valorization technologies
Each of the sub research questions provided their own set of criteria; whereby they deeply intertwine one another and are problematic to decouple. Attributes of porcine blood is a good start because without the characteristics of the raw material, it is almost impossible to list either feasible valorization technologies or suitable suppliers. Therefore, by linking information from every sub research question together, a whole list of criteria is unveiled, they are physical, chemical, and biological properties of blood, amount and type of blood, company's requirements, particular technologies for blood valorization, and suppliers who met the company's requirements and are able to implement suitable equipment for valorization.

5.1.2 Economic potential of valorization methods

This subsection aims to answer the following sub research question:

What criteria are of use to analyze the economic potential of valorization methods of porcine blood from the ABC slaughterhouse?

a) What is the suitable business strategy that could be applied to analyze the economic potential?
b) Who are the potential customers for valorized porcine blood?
c) What is the current market size of valorized porcine blood?
d) Among the currently used valorization methods and the proposed methods, which methods provide the greatest economic benefits to the ABC slaughterhouse?

Criteria for analyzing economic potential of proposed valorization methods can be obtained through both desk research and field research.

Suitable business strategy

From the literature study in Chapter 2, the PESTEL framework, Porter's five forces framework, and a SWOT analysis are suitable theories for assessing the proposed valorization technologies. The framework exposed influential factors that are likely to affect the valorization project of the company while a SWOT analysis detailed the feasibility and economic potential of the selected methods. Therefore, the suitable business strategies is hiring a research and development manager with expertise in valorization technologies so that he can thoroughly investigate the valorization scheme IV and starting the production when the new slaughterhouse is running.

The suggested stage 2 strategies for the company are hiring R&D staff to develop their own unique blood products and co-operate in developing new products with other firms, for example, AAA Group or Sonac BV. To hire R&D staff to work at the company, a well-equipped laboratory is requisite; nevertheless, this will require a large amount of investment to build a high quality lab. The estimated costs of building a new lab can be from €500,000 to €1,000,000 or more. Apart from hiring R&D staff, the company can co-operate with a university or a research center, which will cost the slaughterhouse around 2,000 €/month/person until products are developed.

Potential customers

Medicinal products are the highest added value of valorized products. However, they are too complex and inconvenient for the company to start with in this field. Thus, the second and the third levels from the value pyramid are selected as target segments; human foodstuff and animal feed. The purpose of searching for potential customers is to assure that valorized products meet with customers' demands. The full list of potential customers is displayed in Table 16.

Table 16: List of potential customers for hemoglobin powder and plasma powder

Country	Company	Website	Type
Belgium	Intraco	www.intraco.be	Feed
Bulgaria	Huvepharma	www.huvepharma.com	Feed
France	Vitalac	www.vitalac.eu	Feed
France	Here & There	www.hereandthere.fr	Feed
France	Alphatech	www.alphatech-france.eu	Feed
Korea	Daeho	www.daeho.com	Feed
Netherlands	Nutreco	www.nutreco.com	Feed
Netherlands	Agrifirm	www.agrifirm.com	Feed
Netherlands	De Heus Feed	www.deheus.com	Feed
Netherlands	ForFarmers	www.forfarmers.nl	Feed
Netherlands	Hendrix UTD	www.hendrixutd.nl	Feed
Netherlands	Boerenbond Deurne	www.boerenbond-deurne.nl	Feed
Netherlands	Sonac	www.sonac.biz	Food & Feed
Netherlands	AAA	www.AAA.nl	Food & Feed

Switzerland	Chemoforma	www.chemoforma.com	Feed
Thailand	Thai Foods Group	www.tfg.co.th	Feed
Thailand	Laemthong	www.laemthong.com	Food & Feed
Thailand	Charoen Pokphand Foods	www.cpfworldwide.com	Food & Feed
Thailand	Krungthai Food	www.ktfood.co.th	Feed
Thailand	Sun Group	www.sunfood.co.th	Food & Feed
Thailand	Lee Feed Mill	www.leepattana.com	Feed
Thailand	Centaco	www.centaco.com	Feed
Thailand	Betagro	www.betagrofeed.com	Food & Feed
USA	Varied industries	www.vi-cor.com	Feed
USA	Cargill (Thailand)	www.cargill.co.th	Food & Feed

Additionally, the potential manufacturers in food additives are Ajinomoto, Givaudan, Archer Daniels Midland (ADM), BASF, AVEBE, and Danisco (DuPont), while key players in the animal feed additives segment are Addcon Group, Adisseo France S.A.S, Kemin Industries, BIOMIN Holding, Elanco Animal Health, DSM, Novus International, Nutreco, Novozymes, Evonik, Archer Daniels Midland (ADM), BASF, Cargill, and CHR Hansen. Aside from the fact that these are potential suppliers from food and feed industry, they are also prospective buyers because they can used valorized blood products as raw material in their blood processing.

Current market size

Market size is often used for determining the attractiveness of the market of interest. In this case, human foodstuffs and animal feed are our target markets. Due to the complexity of food and feed businesses, the researcher used the food additives market and the feed additives market as standard models to evaluate the economic potential. From subsection 2.2.2, the expected growth rate is 3 to 4% from 2013 to 2020; the estimated market sizes in the next six years are around 36 and 20 billion US dollars for food additives and feed additives, respectively.

Comparison of currently use methods and proposed technologies

An estimation of future income from the conventional bleeding technique, in which blood is divided into human consumption and destruction blood, is a deficit of -300 €/day; whereas scheme IV will generate revenue of 11,200 €/day, which is almost 40 times higher. With the shortest break-even point (BEP) of 1.77 calendar years, and the highest return on investment (ROI) of 107.33%, these two values also prove that the economic potential of scheme IV is higher than other schemes. However, scheme IV also requires a large sum of money of around five million euro in total before the company passes the breakeven point. Therefore, it is obvious that scheme IV will provide the greatest economic benefit to the company.

Criteria for analyzing economic potential of valorization technologies

In order to determine success or feasibility of valorization technologies, several criteria are gathered from sub research questions. Costs and benefits along with market size, potential customers, BEP, and ROI are criteria that the researcher used for analyzing economic potential of proposed technologies. Harmony of criteria can be used to evaluate the economic potential. If one of the criteria does not fit with the technology such as very small market size, it means that the proposed method is low in economic potential.

5.1.3 Effective EU Laws and regulations

This subsection aims to answer the following sub research question:

What EU laws and regulations are effective against both porcine blood as raw material and valorized porcine blood?

a) What EU law and regulations are effective against porcine blood as raw material?
b) What EU law and regulations are effective against valorized porcine blood?

Effective EU laws and regulations can be found on the website of European Union law (EUR-Lex). Due to the company's requirements, valorized products fall into human foodstuff and animal feed categories, so that the laws and regulations are related to food and feed.

Effective EU laws and regulations for porcine blood as raw material
In our literature study in section 2.1, blood obtained from a healthy and live animal is sterile, but bleeding techniques determines the category of blood to be either human consumption or 'category 3' raw material. The killing technique that determines the category of blood is laid down in Council Regulation (EC) No 1099/2009, while hygiene of porcine blood is controlled by Regulation (EC) No 852/2004, (EC) No 853/2004, and (EC) No 854/2004. These regulations are meant to control blood for human consumption. The researcher suggests the company conform to these regulations because blood intended for human consumption can be valorized to either foodstuffs or feed, but 'category 3' blood cannot be processed into foodstuffs. Details of the regulations involved are described in subsection 2.2.6. Nonetheless, there is no direct change in laws and regulations about porcine blood as raw material, the only changes made to offal and viscera examination of pig carcass appear in Commission Regulation (EU) No 218/2014 and (EU) No 219/2014.

Effective EU laws and regulations for valorized porcine blood
As the valorized products are human and animal feed, there are two sets of laws and regulations that must be complied with. Valorized porcine blood products for human consumption are mainly controlled by the food hygiene regulations package, which comprises of Regulation (EC) No 852/2004, (EC) No 853/2004, and (EC) No 854/2004. These regulations provide the requirements for production and standard of foodstuff. Valorized blood products for animal feed are mainly controlled by Regulation (EC) No 1069/2009 and (EU) No 142/2011. Similar to foodstuffs, animal feed regulation also controls hygiene and safety of products. In addition, Regulation (EC) No 178/2002 lays down general requirements for both foodstuff and feed.

5.1.4 Final conclusion

This last subsection aims to answer to the main research question:

"What is the most suitable valorization method for porcine blood from the ABC slaughterhouse in terms of technological feasibility, local and international economic potential, and the recently changed EU regulations?"

The most suitable valorization method
According to the literature study in section 2.2.4, five out of seven methods are suitable for the company, where they are combined into five valorization schemes. Technology itself is not adequate to generate answers to this question, but the answer will be revealed when the technological aspect is united with economic and legal aspects. However, the legal aspect is not an option for the company to choose, as they must comply with it, so there is only an economic aspect left for consideration. The calculations of costs and benefits of every scheme are displayed in section 4.4. From this information, scheme IV will provide the greatest benefits to the company with a BEP period of 1.55 years and ROI of 107.33%, but the company should consider the total investment costs, which will be almost five million euro. On the other hand, scheme I requires the lowest investment of around one million euro, but it has the longest period of BEP of 7.11 years of operation to cover asset costs, but the ROI is 3.41%, which is very low compares to scheme IV. **Therefore, the researcher recommends scheme IV valorization method for the company because of the shortest period of BEP, the highest revenue among others, the highest ROI inter alia, and compliance with EU laws and regulations.**

5.2 Discussion

Limitations of this research and recommendations for future research are discussed in this section.

5.2.1 Relevance

As described in the introduction, over 50% of food consumed comes from the manufacturing sector. This research was conducted on the by-products and wastes from a pig slaughterhouse with an intention to valorize them. The company currently has their own basic valorization by selling every part of the pig to other firms. This research attempts to introduce new valorization methods concerning new technology, economic potential and legal aspects that might be of importance for development and selects a valorization method for the ABC slaughterhouse. Although, many valorization technologies are described in literature, there are a handful of methods that are specified for porcine blood. Most advanced techniques that can commercialize products are kept confidential. The relevance of this research lies in the fact that it builds on the empirical research on by-products and waste information and investigates their suitability to specific valorization technologies. The conclusions, therefore, provide essential information to the ABC slaughterhouse of options available to them and assist in selecting feasible technologies resulting in an increased success rate.

5.2.2 Limitations

The main limitations of this research lie in validity, particularly the generalizability of conclusions. Firstly, even though the research strategy is a business case study, there are in total fifteen slaughterhouses operating in the Netherlands. The pig slaughterhouse in this research is located in XYZ and this reduces generalizability of this research because it cannot be argued with any certainty that the selected company really represent other slaughterhouses. Due to geographical and demographical differences, other firms might be facing different problems requiring other valorization technologies.

Secondly, this research focused solely on the ABC slaughterhouse so it might not represent valorization solutions in other slaughterhouses such as cattle, sheep, or poultry. Thirdly, the legal aspects of this research were limited to EU laws and regulations, thus some of them might not comply with the rest of the world, which will cause problems when the company expands their markets. Lastly, this research was conducted as a plan for valorization in the next fifteen years so all information provided from this report might change, and the company might find it impractical.

5.2.3 Recommendations and further research

Based on the results of this research, the following recommendations for further research can be given:

1. This research can be conducted with all of the influential factors from the PESTEL framework, which will enhance the reliability in selecting suitable valorization technologies. Also with more aspects of legal and economic theories, better insight in assessing suitability of valorization technologies can be achieved.
2. The scope of this research can extend to other pig slaughterhouses in the Netherlands, which will improve the validity of results and might be able to pool and share valorization methods among pig slaughterhouses.
3. The scope of this research can extend to other by-products and wastes from the ABC slaughterhouse which will broaden the valorization methods for the company to choose investment. Because conclusions from this research are that the technologies consume a lot of energy during production, it would be better if the next research project covers valorization methods that generate sustainable energy from pig slaughterhouses' by-products and waste stream.
4. This research can be conducted with the focus on valorizing by-products and waste into medicinal products because they can generate higher revenue than presented foodstuff and feed products.

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