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Biomass Valorization Using Green Technologies: an Entrepreneurship Approach

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Abstract

The aim of this thesis project is to suggest a market application for Subcritical Water Extraction Technology (SW Technology), which uses water based processes. It is a green, versatile and environmental safe technology.

The first step was to study in detail the technical features of the technology in order to provide a set of possible market applications focused on waste valorization. Selection criteria were considered for the raw material as well as for the market application and resulted in the choice of two applications: i) potato starch from Industrial potato wastes and ii) pectin from Industrial citrus and apple peels. From further market application, potential production and market need analysis, it transpired that pectin for food applications is the best promising application from the market point of view.

The business model proposes the creation of a start-up, BioADD, constituted by a team of highly qualified specialists in different areas. BioADD will produce the product PectiCitrus from orange wastes adopting a *factory in factory* business model with the company Lara, Laranjas do Algarve. The European pectin market is valued in 372 M€ and BioADD will target 3% of it in the first year of operations. BioADD business model is Business to Business and PectiCitrus will be sold to European Distributing companies. The business model is developed for a five years time period, where the first year is dedicated to technology scale up studies in order to fit Lara orange peels production. The necessary investment to create BioADD is about 850 000€ with return of investment period in three years and internal rate of return of 32%.

PectiCitrus is positioned in the market as a sustainable and competitive product. The Food industry market application is large. Although BioADD technology detains the potential to cover all applications, BioADD will focus on three major markets: i) Soft drinks, ii) Jams, jellies and marmalades and iii) Yoghurt and acidified milk drinks.

Key-words: Subcritical Water technology; Pectin; Galacturonic acid; Waste Residue Valorization; E440 food additive; Sustainable products; Environmentally-friendly products

Resumo

O objectivo deste trabalho prende-se com a sugestão de uma aplicação de mercado para a tecnologia de Extracção com Água Subcrítica, que utiliza como solvente a água. Esta tecnologia caracteriza-se por ser verde, versátil e ambientalmente segura.

A primeira etapa do projecto foca-se no estudo das diversas possíveis aplicações de mercado para a tecnologia em estudo, tendo como fundamento a valorização de resíduos. Os critérios de selecção foram considerados de modo a avaliar tanto a matéria-prima como também a aplicação final resultante. Desta análise resultaram duas possíveis aplicações: i) obtenção de amido de batata proveniente de resíduos industriais de batata e ii) obtenção de pectina proveniente de resíduos industriais de citros e maçã. Ambas foram posteriormente analisadas em termos de capacidade de produção, necessidade de mercado e respectiva aplicação. Concluiu-se que a opção mais interessante numa perspectiva de mercado é a pectina para aplicações no sector alimentar.

O modelo de negócios pressupõe a criação de uma *start-up*, designada BioADD, constituída por uma equipa de especialistas altamente qualificados em diferentes áreas. A empresa BioADD vai produzir o produto PectiCitrus a partir de resíduos industriais de cascas de Laranja adoptando um modelo de negócios *factory in factory*, i.e., em parceria com a empresa Lara, Laranjas do Algarve. O mercado Europeu de pectina está estimado em 372 M€, sendo que a empresa BioADD tem como objectivo de mercado satisfazer 3% deste no primeiro ano de comercialização do produto PectiCitrus. O modelo de negócio é *business to business* e passa por venda do produto a empresas distribuidoras Europeias. Este encontra-se estimado para um período de cinco anos, sendo que no primeiro ano decorrerá investigação e *scale up* da tecnologia de modo a adequá-la à capacidade produtiva da empresa Lara. O investimento necessário para criar a empresa BioADD ronda 850 000€, com um período de retorno de três anos e taxa interna de rendabilidade a 32%.

O produto PectiCitrus deve ser posicionado no mercado como bastante sustentável e competitivo. O mercado da Indústria alimentar é possui diversas aplicações onde o produto pose ser utilizado. Apesar da empresa BioADD ser capaz de satisfazer estas aplicações na sua maioria, a empresa foca-se em três principais mercados: i) Bebidas gaseificadas, ii) Doces, compotas e marmeladas e iii) Iogurtes e bebidas láticas acidificadas.

Palavras-chave: Tecnologia de Extracção com Água Supercrítica; Ácido Galacturónico; Pectina; Aditivo alimentar E440; Valorização de Resíduos; Produtos sustentáveis; Produtos amigos do ambiente.

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List of Abbreviations

BioADD	Bio *Additives*
BOD	Biochemical Oxygen Demand
CHP unit	Combined Heat and Power unit
COD	Chemical Oxygen Demand
EU	European Union
FCT	Faculdade de Ciências e Tecnologias
HM Pectin	High Methylated pectin
ISO	International Organization of Standardization
INE	Instituto Nacional de Estatística
LM Pectin	Low methylated Pectin
NCW	Near-Critical Water
PERC	Pittsburgh Energy Research Center
PHW	Pressurized Hot Water
PHAs	Polyhydroxyalkanoates
SW Technology	Subcritical Water Technology
UNL	Universidade Nova de Lisboa

1. Executive Summary

The thesis project "Biomass Valorization Using Green Technologies: An Entrepreneurship Approach" was a research project focused on innovation, waste valorization and in the technical challenge of taking technologies form the laboratory to the market. The aim of this project was to understand the best market application for the technology under study and develop a strategic line of market implementation for it with success.

The technology is based on the Subcritical Water Extraction Technology who uses water as solvent. This technology is versatile, environmental safe and pollutant free. It has the potential to hydrolyse biomass that otherwise requires toxic and environmental harmful solvents, as well as extreme conditions to decompose large molecules into smaller valuable ones. The technical features of the GEI technology are presented in Chapter 2.

With the technology technical features in mind, a brainstorming exercise regarding its possible market applications was conducted. The brainstorming focused on the valorization of industrial residues, particularly if they represent an environmental issue and have an expensive treatment. The resultant options were then selected according to several classification criteria that analysed the raw material and the correspondent market application. The selection criteria for raw material were: i) cost of waste treatment, ii) availability, iii) geographical location, iv) environmental sustainability and v) legal sustainability; the selection criteria for the market application were: vi) price, vii) market size, viii) market value, ix) competition and x) market trend.

The resultant market appealing applications were: production of potato starch from industrial potato wastes and production of pectin form apple & citrus industrial peel wastes. Also, the company was contacted by the company Campotec seeking assistance in solving their large volume of potato wastes. Both potato starch and pectin market analysis were performed in terms of potential production, specific market applications and market need. It was concluded that pectin obtained from citrus peels was the most valuable application. The resultant product is named PectiCitrus. This analysis is presented in chapter 3.

Pectin is a natural substance which is present in many vegetable and fruits. It is a food additive (E440) and commodity product with jelling, thickening, stabilizer and texturizer properties. From market analysis, it resulted that PectiCitrus is mostly used in the Soft drinks (96%), Yoghurt and acidified milk drinks (3.2%) and Jams, jellies and marmalades Food Industries (0.6%). The European pectin market is estimated in 372 M€ (33x higher than the Portuguese market) and the later three Food Industries markets are estimated in 282 M€.

The start up business model is *business to business* and involves a partnership with a fruit processing company. The business model adopted strategy is *factory in factory*. BioADD is constituted by a team of highly qualified specialists in different areas. PectiCitrus manufacture will take place inside the fruit processing company facilities and these operations will be controlled by BioADD team members. BioADD intends on establishing a profitable partnership with the company Lara, Laranjas do Algarve.

PectiCitrus product will be sold to European Distributing companies. The goal is to conquer 5% of European Pectin market in the time period of five years.

The pectin market is very competitive and dominated by major international players. PectiCitrus differentiates from its competitors by its environmental sustainability and competitive price. Competitors traditional employ toxic, flammable and environmental harmful solvents to obtain pectin from citrus peels and apple pomace. PectiCitrus only requires the solvent water. Also, PectiCitrus is an added value product from a natural organic source that must be taken into account by customers given the growing market trend where people are increasingly aware of the biological green source of the food ingredients to make health choices.

The concerns about intellectual property and the certifications required by the regulatory authorities are important points to take into account when an idea is turned into a sellable product. BioADD technology comprises production of PectiCitrus through subcritical water extraction technology. The possible Industrial patentability of BioADD technology is discussed in chapter 5.

The marketing and Development and operations plan define the strategies that the company will endure in order to successfully enter the market. These are located in chapter 6 and 7, respectively. The marketing plan encloses the Vision, Mission and Objectives of BioADD, as well as the SWOT and Market Mix analysis. The last comprises the Product (main attributed of PectiCitrus, BioADD logotype and slogan), Price (based on the market price practiced by competitors), Place (indirect distribution to the European market through European Distributors) and Promotion (focused on direct contact with customers, conference assistance and website development). The development and operations plan explains the key steps required to convert the initial idea into a market product, as well as equipment and geographical location.

The last chapters concern the BioADD financial plan and critical risks. In both, real numbers were used in order to support future projections.

Because we belief in the future of this project, hence forward this thesis is written in the first person.

2. Description of Technology

Description of BioADD technology is of vital importance to understand the building blocks of the present business plan. This chapter aims to clarify the basic concepts of the technology and its major achievements and technology developments.

Technology Contextualization

Subcritical water refers to liquid water at temperatures between the atmospheric boiling point and the critical temperature (370˚ C) of water. Alternative terms include pressurized hot water (PHW), hot compressed water (HCW), near-critical water (NCW) or superheated water. Subcritical water is an environmentally friendly solvent and attractive medium for a variety of applications. It is cheap, non-toxic, non-flammable and non-explosive [1].

The interest in subcritical water was developed in the late 70s of the 20th century encouraged by the first oil crisis, environmental concerns and research of supercritical fluids [2]. Alternative fuels, waste disposal, coal and biomass (biological organic material) conversion are the main reasons for the growing interest in this technology. Biomass is one of the most abundant sources of renewable energy because it stores sunlight energy in chemical bonds and can be converted into a liquid energy carrier [3,4].

Biomass represents the most promising source for production of sustainable fuels compared to the generation of electricity from alternative sources like wind, water and sunlight [4]. Presently, Biomass stores about 3×10^{21} J of incident light in chemical bonds per year [4]. 3% of the annually grown biomass is economically exploited and esteemed to be 186 million tonnes in 2010 in Europe. Increase in biomass exploitation is expected to be around 243-316 million tonnes by 2030. Energy from biomass additionally avoids the increase of carbon dioxide in the atmosphere and helps to meet the obligations of the European Union to reduce the carbon dioxide release. Biomass compounds from agriculture and food industries can be gasified to produce fuel gases or a liquid bio-oil [5]. Both can be used subsequently to produce electricity.

The major targets as future commodities for biofuel production are lignocellulose and microalgae based biomass. However, these biomass sources possess disadvantages; their compositions vary considerably amongst the individual plant species, for instance lignocellulose is considered to be highly resistant to hydrolysis. Furthermore, the raw biomass often contains large amounts of water. These properties illustrate the difficulty for direct integration of biomasses into existing chemical processes. Therefore, the search for technologies to break down biomass constituents into defined products that can be used as raw materials for fuel production and chemical industry represents a major challenge. Based on its solvent properties in combination with the often considerable intrinsic water content of natural biomass, Subcritical water is often considered as a potential solvent for biomass processing. Other solvents require previous removal of water content as opposed to the technology in study.

Subcritical Water Technology properties

BioADD technology is based on Subcritical Water Extraction Technology. Further is discussed the chemical technical features of this technology.

A pure substance can exist in a solid, liquid or gas phase which is defined by phase boundaries. A pure substance pressure-temperature phase diagram presents a triple point in which three phases can be distinguished: solid, liquid and gas (figure 2.1). The point on the boundary curve is called the critical point; when the temperature and pressure increase above the critical point, liquid and gas phases coexist [6].

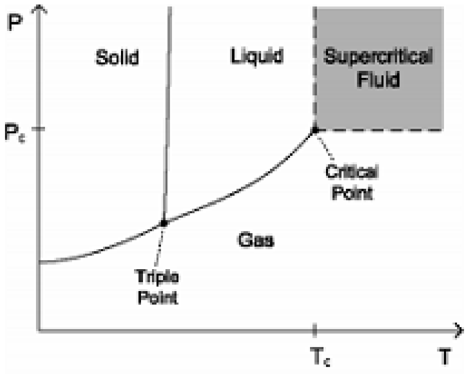

Figure 2.1 - Pressure-temperature phase diagram for a pure substance

Subcritical Water extraction technology is a process conducted with water at medium pressures and temperatures with the goal of hydrolyzing large organic molecules into smaller ones. It can be used with solid or liquid samples [7]. The range where water is considered to be in subcritical conditions is between 100˚C (water boiling temperature) - 370˚C and around 10 – 25 MPa (Figure 2.2) [8]. At these conditions water is still in a liquid state due to pressure levels but acquires interesting and valuable properties as a solvent that does not exist at environmental conditions. Namely, reactant and catalyst properties [8]. Subcritical water is stable under these conditions by heating it in a sealed container with a headspace, where the liquid water is in equilibrium with vapour.

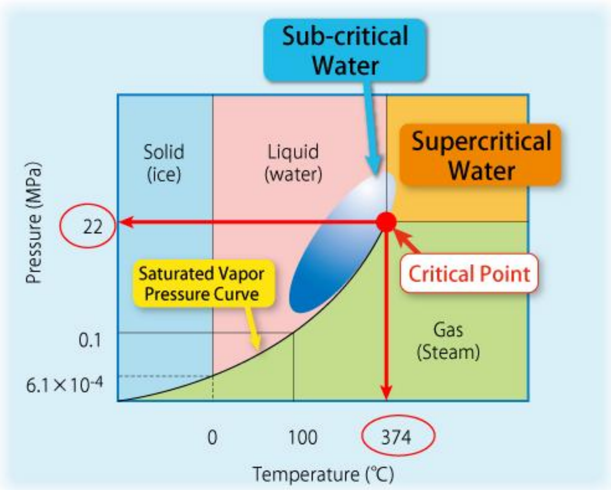

Figure 2.2 - Water Phase Diagram

Near the critical water point, organic substances demonstrate low viscosity and high solubility. This leads to more efficient, fast and homogeneous reactions [8]. Water dielectric constant decreases from 78 F m^{-1} (25ºC and 0.1 MPa) to 14.07 F m^{-1} (350ºC and 20 MPa) [8] allowing increased solubility of hydrophobic organic compounds. Water changes from a solvent for ionic substances to a solvent for non-ionic substances [9].

The ionic product of water (KW) suffers alterations from 10^{-14} at ambient conditions to 10^{-12} at subcritical conditions [8] resulting in higher levels of available OH^- and H^+ ions. This means that many acid or base-catalyzed reactions are accelerated, such as biomass hydrolysis. Below critical point, water is a solvent for non polar substances in opposition to ambient conditions and its reactivity increases as conditions get closer to the critical point [2,3].

Subcritical water has the same transport properties in solvent power for organic, salt and gases substances; these are the same as supercritical gases. Density is high and similar to liquid densities but vary with slight changes in pressure and temperature [2]. Increase of temperature reduces surface tension at moderate pressure and viscosity of water, which results in an enhanced solubility of species; density of subcritical water is the same as a normal gas and solubility is the same as liquids [2,3].

Water is a green, non-toxic and an inexpensive solvent [10]. Subcritical Water is therefore an eco-friendly technology since it doe not use toxic organic solvents [7]. Through its use it is possible to extract/hydrolyse several compounds reutilizing the solvent water with low or absent gas emissions. Water is a cheap solvent and being further recycled lowers its costs. It is also chemically stable, safe, and harmless to the environment.

→ Hydrolysis and Extraction

Subcritical water process transforms Biomass (biological organic material) polymers into monomers by two major categories: Hydrolysis and Extraction procedures.

Hydrolysis - Due to water characteristics in the subcritical phase regarding the available H^+ and OH^- ions and its reactivity, it is possible to hydrolyze organic compounds into their basic monomers. This is achievable through the hydrolysis reaction [2], where a substance is split by water H^+ and OH^- ions (figure 2.3). Therefore, subcritical water is able to break down large organic molecules into its basic constituents, resulting in a liquid, often called biofuel or bio-oil that possess energetic resource potential.

$$A{-}B + H{-}OH \rightarrow A{-}H + B{-}OH$$

Figure 2.3 - Water hydrolysis reaction

Extraction – Similarly to Hydrolysis, this application also consists in hydrolyzing large organic chain molecules (polymers) into smaller pieces (monomers). But the principal purpose is to apply temperature and pressure variations in order to solubilize different organic compounds with low value into high-value products. These have several potential market applications for example as nutraceutics and Food Industry. When water is heated to a temperature between the ebullition and subcritical point it is extracted inorganic and nonpolar compounds [11]. At lower temperatures, ionic and polar species will then be extracted. Water removes nonpolar compounds by interacting with the substract and reducing binding forces [11]. This extraction is a fast and selective procedure.

In terms of market, subcritical water hydrolysis of biomass into smaller monomers is able to provide small valuable molecules, bio-oil and electricity as major class applications. Individual applications depend on the source of the raw organic material because its chemical constitution will determine how water will interact with it; water ions may or may not have easy access to the building blocks of the raw material. Biopolymers can react with high-temperature water in very short residence times and with high rates of conversion. The achievable products are manifold and can be varied to a large extent by changing operating conditions. Subcritical water technology is therefore very versatile given it allows multiple outcomes for different organic biopolymers [1].

Extraction of bioactive substances from biomass products using subcritical water involves three sequential steps: **i)** Desorption, where solutes must diffuse from the core of the materials to the surface, **ii)** Desorption that involves transfer from the surface into the stagnant fluid layer and **iii)** Dissolution, where solutes are dissolved in the extraction fluid and eluted out of the extraction cell [12]. The extraction rate is limited by the slowest of the three steps.

Processes in pilot or demonstration scale

The commercial application of technology developed in the laboratory to industrial application requires the scaling up from the bench to the industrial scale, representing an increase of a thousand times more. It involves a number of equipment designs, process and technology risks. The incremental scale up of process technologies to the pilot scale demonstrates the scalability of the technology and reduces the risks & costs associated with commercialization. This subchapter overviews the processes in pilot or demonstration scale in literature:

→ The PERC (Pittsburgh Energy Research Center) process consists in converting lignocellulosic material into bio-oil. It was performed by Lawrence Berkeley laboratory and included a pre treatment of the wood material to weaken it. The pre-treatment involved a mild acid hydrolysis (pH 1.8) at 180˚C for 45 min [13];

→ In Hamburg University of Applied Sciences it was demonstrated a process for the conversion of chipped and dried biomass [8]. The process is accomplished in a bottom-phase reactor under high-pressure (8.0 MPa) and temperature (250 - 500˚ C) with the addition of hydrogen to produce oil, water, char and gas. The semicountinuous test plant in Hamburg University of Applied Sciences converted 5Kg/h of biomass;

→ In Copenhagen, Denmark, it was developed a pilot plant that converts organic waste to oil in the presence of a homogeneous (K_2CO_3) and a heterogeneous (Zirconia) catalyst. Subcritical conditions employed are 280 - 350˚C and 22.5 - 25 MPa [14]. The system is called CatLiq technology and the pilot plant operates with 20L/h;

→ A prototype sludge-to-oil reactor system (STORS) able to process undigested municipal sewage sludge with 20% solids at a rate of 30 L/h was developed in the 80s by EPA's Water Engineering Research Laboratory, in USA [15]. The resultant fuel had a heating value of around 36 MJ/Kg and maintained about 73% of the energy contained in the feedstock;

→ In Japan a plant capable of processing 5 tons of dewatered sludge per day was erected in the 90s [8]. It operated around 300˚C and 10 MPa. The product obtained was heavy oil with a heating value of 31 - 39 Mj/kg. This was a continuous STORS process, where the reactor functioned as a high temperature and high-pressure distillation column, allowing for gas and other volatiles to be continuously removed. Liquid was also continuously removed from the bottom of the reactor.

<u>Commercial Projects</u>

In the last decade several commercial applications appeared in the market. Some of them are presented below:

→ A Near-critical facility performs the hydrolysis reaction process on toluene diisocyanate (TDI) residue [16]. The facility was built by Hanwha Chemical Corp. for Korea Fine Chemical Co in 2008. The residue is produced from the manufacture of TDI, a chemical precursor in the production of polyurethane. The hydrolysis reaction converts the waste material back to the intermediate toluene diamine, which can then be recycled back into the TDI manufacture process [16].

→ The "SlurryCarb" process operated by EnerTech Environmental with subcritical water technology, chemically converts municipal sewage sludge (MSS), municipal solid waste (MSW), and other organic wastes into a high-energy liquid fuel (or slurry) that is cleaner to combust than most coals [17]. This liquid fuel is called E-fuel. The plant is able to process 683 tons of waste per day. The plant is able to process 683 tons of waste per day [18].

- → A demonstration plant in Netherlands uses the process designated HTU or Hydro Thermal Upgrading for the thermochemical liquefaction of biomass into oil [19]. Biomass raw materials include domestic waste, residues from agriculture and forestry and peat. The product is 'Biocrude', a heavy organic liquid with 10-15%w oxygen and a heating value of 30-35 MJ/kg [19].
- → In 2004 the first scale-up plant was inaugurated in Missouri (USA) and converted around 250 tons/day of turkey offal and fats into approximately 500 barrels of a fuel oil [20]. There is however no available information of the reaction operating characteristics and in 2009 it was shut down.

BioADD Technology

BioADD business is to produce PectiCitrus from orange peels through subcritical water extraction technology. BioADD technology is the name given to the sum of three individual operations that will result in the final commercialization of the product PectiCitrus. The operations are outlined in figure 2.4. Further is discussed the objectives and elements of each operation.

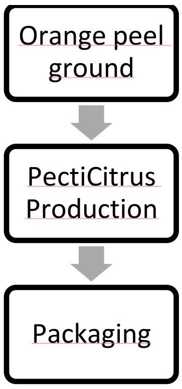

Figure 2.4 - BioADD technology general operations

Orange Peel Ground

The purpose of this operation is to obtain milled orange peels. The dry raw material orange peels stocked in a tank (previously received from the orange processing company) will enter a crusher machine to be milled into micrometer size. The small size is important to minimize mass transfer limitation during the reactive extraction process [21]. Then, the ground orange peels will enter a transporter that leads them into the reactor.

PectiCitrus Production

This operation consists in producing PectiCitrus from ground orange peels that enter the reactor. The reactor will operate under a batch procedure. This means that orange peels and water will be placed inside the reactor and subcritical water extraction reaction will take place after heating and pressuring the reactor into the proper conditions. In the end of the reaction pectin is dissolved in water containing other elements. This solution may require further purification. Proper extraction conditions will be further studied during the investigation and development year that anticipates product production. In literature the best extraction conditions are 140˚C and 4-30 MPa to extract 150 µl of pectin from citrus peels [21].

To pectin be concentrated form the liquid solution, it will pass through a membranes module where water is recuperated. These membranes operate under the osmosis process. They will separate water from liquid pectin by diffusion of water to salt concentrated gradient. The final concentrated pectin is in the liquid state and needs to be further dried in an Evaporator machine in order to obtain a powder product, the PectiCitrus.

Packaging

In this stage, PectiCitrus is standardized and packed. Standardization refers to the addition of chemical elements like sugar in order to have a product ready to be used in its food application. Standardization conditions will be further developed in the research and development year. Packages are either stocked or immediately commercialized. The following figure 2.5 gives a general overview of the PectiCitrus manufacture procedure.

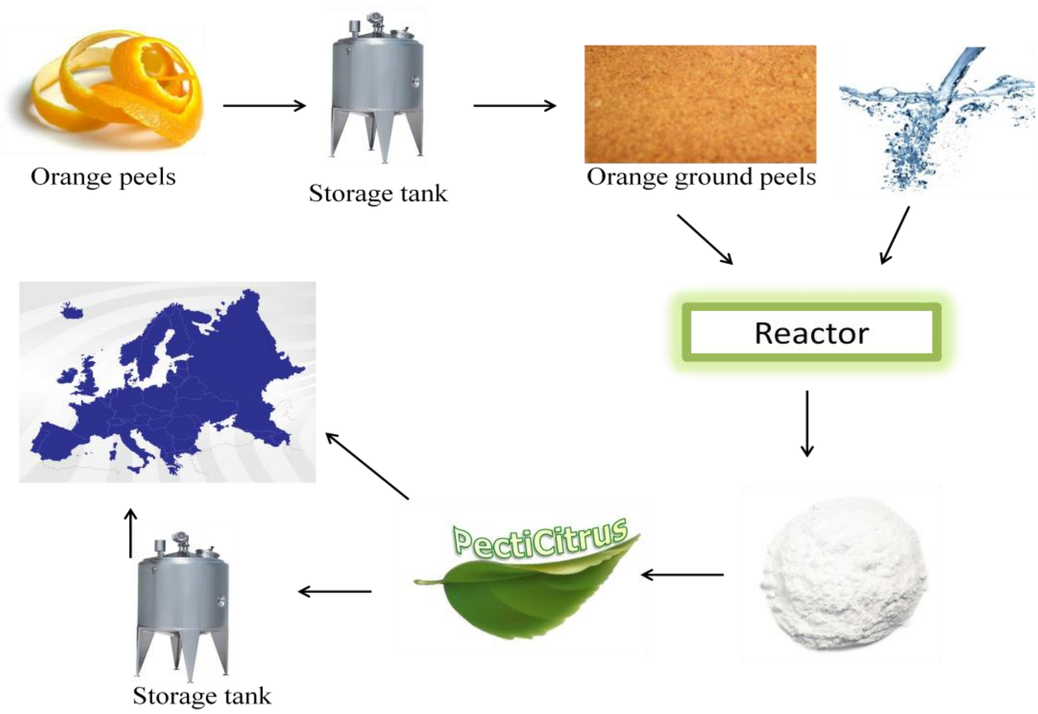

Figure 2.5 - PectiCitrus general production

3. Market Analysis

3.1 Possible Applications

This chapter aims for the discussion of several possible market applications for BioADD Technology. The purpose is to taper the most interesting market application according to several economic, social and environmental selection criteria. The selected market application will then be further studied in the subsequent chapters of this business plan.

In a first approach, applications were chosen according to the raw source material and consequent market application through use of Subcritical Water Extraction Technology. The sub criteria further employed were:

→ Environmental and social components: the focus on these features is driven by the concern with environmental questions;

→ Raw material composition: plastic or organic substances were considered for the reason that subcritical water extraction technology attacks polymers derived from biomass to hydrolyse and extract a valuable substance.

→ Availability of raw material;

→ Current technology treatment.

Table 3.1 enumerates possible applications, raw source materials, the added value product and whether the last is obtained through hydrolysis or extraction.

Table 3.1 – Possible market applications

Raw Material	Extraction/ Hydrolysis	Added Value Product	Possible Market Application
Olive pomace	Extraction	Mannitol	Nutraceutics
Rice bran	Extraction	Phenols	Nutraceutics, Cosmetics
Apple and citrus natural juices production residues	Extraction	Pectin	Nutraceutics, Cosmetics
Potato wastes	Hydrolysis	Potato Starch	Food, Cosmetics, Paper
Paper Industry residues (lignin)	Hydrolysis	Bio-oil	Electricity, Heat
Urban organic and solid residues	Hydrolysis	Bio-oil	Electricity, Heat
Sewage sludges	Hydrolysis	Bio-oil	Electricity, Heat
Hospital residues	Hydrolysis	Bio-oil	Electricity, Heat
Slaughterhouses residues	Hydrolysis	Bio-oil	Electricity, Heat
Rubber/Tires	Hydrolysis	Bio-oil	Electricity, Heat

Hypothesis presented, the next step is to classify each application according to market pain vs. raw material features. The last two are subdivided into several criteria. Market pain is seen as an advantage for BioADD if the market application constitutes a need for customers; it is divided into the following sub criteria: price, market size, market value, competition and market trend. The raw material classification is meant to select the best raw material for BioADD technology; it is sub divided in: cost of waste treatment, availability, geographical location, environmental and legal sustainability.

Table 3.2 presents the classification of each market application and subsequently each application is discussed. The application with the highest score will then be selected as the best amongst all considered.

Table 3.2 - Raw Material and Market Pain analysis of each Subcritical Water Technology possible application

Raw Material	Olive leafs	Defatted Rice bran	Apple & Citrus juice residues	Potato Wastes	Paper Industry residues (lignin)	Urban organic solid residues	Sewage Sludges	Hospital Residues
1. Cost of Waste Treatment	1	1	2	2	0	0	0	0
2. Availability	2	2	2	2	0	1	2	1
3. Geographical Location	2	2	2	2	2	0	0	0
4. Environmental Sustainability	0	0	0	2	2	2	2	2
5. Legal Sustainability	0	0	0	0	1	1	1	1
Subtotal	**5**	**5**	**6**	**8**	**5**	**4**	**5**	**4**
Market Pain	**Mannitol**	**Phenols**	**Pectin**	**Potato starch**	**Bio-fuel**	**Bio-fuel**	**Bio-fuel**	**Bio-fuel**
6. Price	2	2	2	2	1	1	1	1
7. Market Size	1	2	1	2	2	2	2	2
8. Market Value	2	2	2	0	0	0	0	0
Market Pain	**Mannitol**	**Phenols**	**Pectin**	**Potato starch**	**Lignin**	**Bio-fuel**	**Bio-fuel**	**Bio-fuel**
9. Competition	1	0	1	1	0	0	0	0
10. Market Trend	1	2	2	2	2	2	2	2
Subtotal	**7**	**8**	**8**	**7**	**5**	**5**	**5**	**5**

Total	**12**	**13**	**14**	**13**	**10**	**9**	**10**	**9**

Notes: This table aims to classify and analyse each possible raw material and consequent market application for BioADD technology, according to several criteria.
Classification is attributed in the **0 – 2** interval (lowest grade is zero and highest is two).

1. Cost of Waste Treatment - considers if the residue has a high cost treatment technology. This criterion also considers the productivity; in other words $\frac{market\ price \times final\ product\ quantity}{quantity\ of\ raw\ material}$;
2. Availability – considers if the residue is already used in other production processes. The highest score corresponds to the residue being available;
3. Geographical location – concerns the distance of the residue in relation to Portugal and if the residue is located in a specific place or scattered in several locations. 0: the residue is scattered and 2: the residue can be retrieved in a specific place;
4. Environmental sustainability - considers if the residue represents an environmental issue. If so, highest score is attributed;
5. Legal sustainability - regards legal aspects barriers. Score is attributed if the residue must face tight legislation treatment: 0 – there's no legislation, 1 – there's a very strict legislation and 2- there's a legislation which is not very strict
6. Price – Takes into account if there is a necessity for the product and its versatility. Highest score is given to the higher necessity.
7. Market size – represents how many possible consumers the market has
8. Market Value - this criterion considers if the perceived price by the custumer is much higher than the cost of production; that is, if the product has added value. If so, it is considered with high market value
9. Competition – takes into account if there's many competitors in the market and if the product can be differentiated form its competitors

Market trend - considers if there is a growing need for the product. Higher classification is attributed if the application is inserted in a higher growing market trend.

Olive leaves

Olive Oil Industries is one of the most developed and traditional Industries in Portugal. It is a traditional industry of the Mediterranean. The olive oil industry produces a substantial amount of waste and by-products. In the north of Portugal, producers esteem that residues consist in 100 million tones [22]. Besides waste and by-products contained in the olive mill wastewater, the olive pomace also includes skins, seeds and olive leaves that are eliminated before the olives are processed [23]. These residues are undervalued and usually conducted primarily for fertilizers, animal feed and composting [23].

Olive mill wastewaters are composed by 83% water, 15% of organic compounds and about 2% of inorganic chemicals. This wastewater is acidic and contains high concentration of suspended solids, phenols and other organic matter. The organic content is characterized by high levels of chemical oxygen demand (COD), biochemical oxygen demand (BOD), and very high concentration of fat, oil, and grease. The olive mill wastewaters consist in toxic organic materials such as sugars, tannins, polyphenols, polyalcohols, pecins, proteins and lipids [24]. Portugal implemented legislation that obligates Olive Oil Producers to treat their residues because they endanger the ecosystem. For instance, it is required huge levels of water for the treatment [23].

Given the properties of Subcritical water extraction technology, it is possible to apply it to hydrolyze the olive mill wastewater. Organic matter, fat, grease and lipids would be converted into a carbonaceous bio-oil who could then be used as a power source. It can be coupled to a CHP (Combined Heat and Power) unit to provide heat and electricity. Also, reutilization of the water used during the subcritical reaction would diminish the amount of water wasted by olive oil producers.

However, in literature is reported that SW Technology can extract mannitol from olive leafs [25] and there does not seem to be available studies reporting production of bio-oil from olive mill wastewaters with this technology.

Mannitol is a natural occurring sugar and a relative sweetness of 40 - 50% compared to sucrose. Mannitol is assumed to have beneficial effects as an antioxidant (protection against oxidative damage by oxygen radicals) and as a non-metabolizable sweetener. It is also finds application in pharmaceuticals, chemistry and as a medicine. Mannitol is used for press-coated vitamin tablets, aspirin and antacids. Addition of 15 – 20% of mannitol blood it is then protected during freezing and storing [25].

Considering the classification of olive leaves raw material and mannitol productin on table 3.2:

1. Cost of waste treatment - olive leaves are a residue easy to treat in the sense that it can be used for animal feed or composting and does not constitute a danger for the environment. Mannitol market price is about 15 €/kg. Ghoreishi and co workers [25] obtained an extraction yield of 76.75% of mannitol with SW technology. Despite that, olive leaves residues from olive oil Industry quantity of residues may be small to provide measurable mannitol productivity;
2. Availability - olive leaves are used for composting but are available for other treatments given that composting achieves a high valorization of the residue;
3. Geographical location - the residue can be found in olive oil Industries in Portugal;
4. Environmental sustainability - olive leaves do not seem to constitute a very problematic environmental issue;
5. Legal sustainability - BioADD is interested in raw materials which are an environmental danger and hence require legal treatment. In this may lay an opportunity for BioADD to solve an issue for the waste producer. Olive leaves fall outside this category;
6. Price – Mannitol market price is around 15€/kg. Focusing in the antioxidant market application, mannitol is included in the polyol industry. This is 0.98 billion euros market with 1.3% annual growth [26]. Hence it is considered the highest score for this criterion;
7. Market size – Given mannitol possible market applications in the food and pharmaceutical applications it is attributed the score of one;
8. Market value – Mannitol obtained from olive leaves residues detain added value. BioADD consumers would valorize the raw material source and hence pay for it;
9. Competition – the polyol industry has several competitors and mannitol possibly can not be very much differentiated from its competitors. However, it is a large market possibly with market share for BioADD to occupy. Hence classification 1 was attributed;
10. Market trend – mannitol can be seen with having a growing market trend, but it is lower than the evaluated ideas because it is a market whose growth is dependent on the population growth.

Rice Bran

Rice is a cereal crop that feeds more than half of the world's population [27]. About 617 million metric tonnes of rice is annually produced worldwide [27]. About 800 000 tonnes of rice bran is produced per year in Japan [28]. Rice bran is an undervalued by-product of rice milling.

Because rice bran contains around 18% of lipids, it is transformed in rice bran oil. The resultant deffated rice bran has very low value and is usually used for reducing the cost of animal feed or discarded as agricultural waste [29]. Nevertheless, it contains valuable substances such as phenols with antioxidant, UV-B-protecting and anti-tumour activities.

Literature reports that it is possible to extract phenolic compounds from defatted rice bran with SW technology [27,29]. The major phenols are ferulic, p-coumaric, gallic and caffeic acids. It is a very interesting market application for this technology.

Defatted rice bran was analysed in terms of producing phenols to be sold in the pharmaceutical and cosmetics Industry by the criteria in table 3.2:

1. Cost of waste treatment – Ferulic acid price is situated around 370 €/kg. It is a very interesting price but in literature was reported extraction of small amounts, 0.2 – 5g per kg of rice bran [29]; it is unsure if the productivity would compensate the rice bran wastes current treatment costs;
2. Availability – Rice bran is used for animal feed and in agriculture, hence it is considered to be available for phenols production;
3. Geographical location - the residue can be found in the west region of Portugal, where rice production is located;
4. Environmental Sustainability – rice bran does not seem to constitute a very problematic environmental issue;
5. Legal sustainability – rice bran is a residue that is not extremely dangerous for the environment and hence there it does not have a specific legal treatment;
6. Price – Ferulic acid is one of the phenols reported to be extracted in literature [29]. This phenol is very much used in the cosmetic Industry and its market price is situated around 370 €/kg;
7. Market size - The global market for organic cosmetics and personal care products was estimated in $7.6 bn in 2012 and grows 9.6% per year. Skin care for example dominates 32.1% of this market. Phenolic compounds can be used in cosmetics but as well as in pharmaceutical applications. Cosmetics and pharmaceutics are huge markets with many consumers. It is therefore a high potential market dimension for this application;
8. Market value – the product is value-added and BioADD beliefs is would be very valuable in the organic segments of the market;
9. Competition – Besides being big markets, pharmaceutics and cosmetics are also very competitive market;

10. Market trend – phenols are inserted in high growing markets as well as its organic origin is a market trend sought by customers.

Apple & Cirus juice residues

Currently, Industrial citrus and apple wastes are used for animal feed or are incinerated to produce energy. However, their peels contain a valuable carbohydrate that can be extracted to meet several market applications. This carbohydrate is pectin. Pectin exists in all types of fruit peels to a certain extent. Citrus and apple are the fruits that contain the highest percentage of the carbohydrate located in the white part of the fruit named albedo (figure 3.1). Table 3.3 gives an overview of the pectin composition in different fruits and vegetables [30].

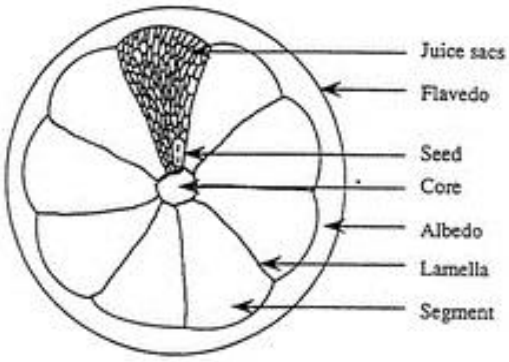

Figure 3.0.1 - Orange fruit schematic constitution

Table 1.3 - Average composition of pectin in some fruit and vegetables

Source	% pectin (dry matter)
Sunflower head	10-15%
Citrus peel	20-30%
Sugar beet pulp	15-25%
Apple pomace	15-25%

Souce: Visse and Voragen, 1995

Pectin is an important polysaccharide with applications in Food Industry, Pharmaceuticals, and other industries. Its importance in the food sector lies in its ability to form a gel in the presence of sugar or Ca^{2+} ions at low pH (acid conditions). It is used in food as the food additive E440. Pectin is a naturally occurring thickening agent. Pectin molecules are long, and easily entangle with each other, causing thickening in proper conditions.

Pectin from different sources does not have the same gelling ability due to variations of the molecular size and degree of esterification [31]. Therefore, detection of a large quantity of pectin in a fruit alone is not itself enough to qualify that fruit as a source of commercial pectin. At the present, commercial pectins are almost exclusively derived from citrus peel or apple pomace, both by-products from juice (or cider) manufacturing.

Besides the content of pectin in each source, they produce slightly different pectins: apple pectin produces a more viscous gel with a browner color than citrus pectin, which produces a transparent elastic gel [32]. This difference correlates to its food applications, for example apple pectin is more suited to certain types of bakery fillings while citrus pectin is mostly used for soft drinks.

According to literature [2133], researchers proved that it is possible to extract pectin from orange residues with SW technology under determined conditions. Hence it is possible to obtain and valorise fruit peels into a value-added compound with market relevance.

This market option was analysed as follows by table 3.2 criteria:

1. <u>Cost of waste treatment</u> – orange and citrus peels from fruit processing companies are usually used for animal feed or deposited in landfills. The market price of pectin is located around 10€/kg, an information provided by the company Herbstreight & Fox. Considering the productivity formula and the fact that BioADD technology is able to extract 75% of pectin from these wastes, BioADD considers this criteria to be scored with 2.
2. <u>Availability</u> – these residues are used either for animal feed, composting or deposited in landfills, which are not able to extract the potential value included in the residues;
3. <u>Geographical location</u> - the residues are located in specific zones of the country, namely west for apple and south for citrus;
4. <u>Environmental sustainability</u> – citrus and apple peels do not seem to constitute a very problematic environmental issue;
5. <u>Legal sustainability</u> – apple and citrus fruit peels are not residues that are extremely dangerous for the environment and hence there it does not have a specific legal treatment;
6. <u>Price</u> – Pectin is a compound with many applications and market price of 10€/kg.
7. <u>Market Size</u> – Pectin is a food additive and inserted in the hydrocolloids market. It is a commodity product that detains a growth similar to population growth, although pectin is being introduced in several new applications due to its properties. Small quantities of pectin produce the necessary effect on the application;

8. Market value – Considering that pectin can be obtained from disposable wastes like apple and citrus, and be sold for an attractive value, then it is an interesting value-added product;
9. Competition – Pectin market is dominated by major key players and prices. It is a competitive market;
10. Market trend – The growing trend of people consuming products with organic and green components leads the custumer to possibly buy pectin and use it in its products. Organic and green raw source materials constitute an attractive growing market trend.

Potato Wastes

Potato is one of the major foods for mankind, situated at the 4th place of importance, behind corn, rice and wheat. It is consumed by more than a billion people in the world [34]. A broad composition of a potato [35] is described in the subsequent table 3.4, followed by a more detailed composition [36] in figure 3.2:

Tabela 3.2 - Potato chemical composition

Elements	Proportion (%)
Water	80
Proteins	2
Lipids	0,1
Carbohydrates	17

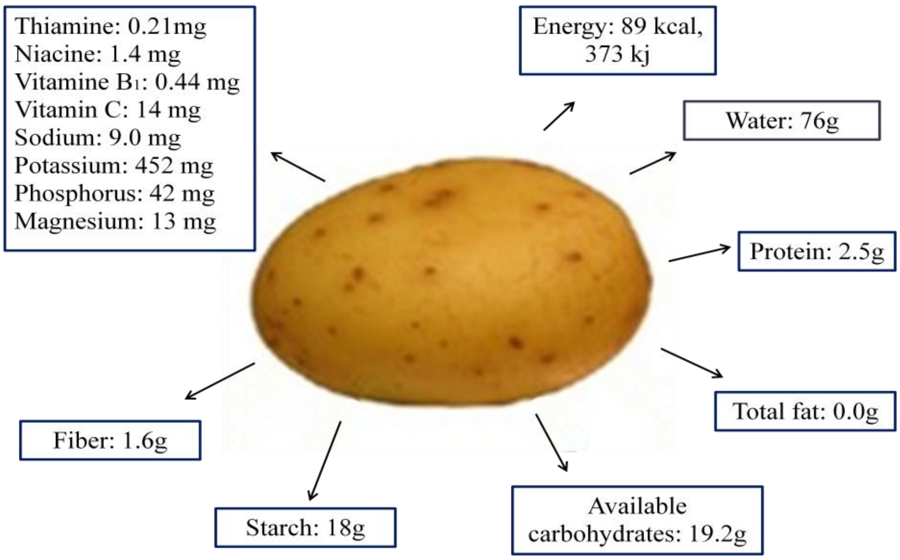

Figure 3.0.2 – Nutritional composition of a raw potato (for 100g of edible part)

Potato peels are a zero value waste of the potato processing plants. Depending on the potato peeling procedure applied, plants losses range from 15 to 40% of potato [35]. These potato peel residues face the same destiny as fruit processing residues; they are mainly used in animal feed or incinerated/placed in landfills. In these arguments there is an opportunity for BioADD technology to take advantage of the wasted nutrient rich potato peels. Another issue in plants like potato plant is that they use large amounts of water and therefore produce great quantities of liquid waste [35]. This actually poses as an opportunity to BioADD technology since it is based on water recirculation.

Potato wastes can have several sub product applications [37,38]. They are as follows:

- → Starch Production
- → Ethanol Production
- → Fermentation to produce high added value products
- → Animal feed
- → Composting
- → Anaerobic fermentation
- → Small scale pyrolysis
- → Pharmaceutics (antioxidant activity due to phenol presence)
- → Fructose, glucose, fructose-glucose syrup

According to table 3.4, carbohydrates constitute a high portion of potato peel wastes. Within this it is found starch, one of the most abundant renewable organic compounds on Earth [39]. Starch is largely used in Food, Paper, Chemical, Textile and other Industries.

The potato starch market option was analysed as follows by table 3.2 criteria:

1. <u>Cost of waste treatment</u> – potato starch has a very low market price, 0.49 €/kg. However, large quantities of potato wastes are available given that potato is the 4th staple food for mankind. Hence, it is assumed that potato starch productivity would be reasonable, although literature does not support potato starch extraction with BioADD technology;
2. <u>Availability</u> – potato peels are used for agriculture, animal feed or as a feedstock for anaerobic digesters and starch based biodegradable packaging [37]. But, it is considered the residue is available because it is present in large quantities;
3. <u>Geographical location</u> - the residues are located in specific zones of the country, namely in the centre of continental Portugal;
4. <u>Environmental sustainability</u> – unlike the market option previously analysed, potato processing plants face an environmental biological problem. Due to operating conditions, the residues contain recalcitrant wastes and wastes with high

COD/BOD_5 ratio [35]. Potato processing plants must perform a biological treatment before releasing their residues;

5. Legal sustainability – despite the necessity of biological treatments in waste processing plants, potato peels do not require legal treatment;
6. Price – potato starch market price is around 0.39 €/kg. It is employed in several market applications, especially as a food additive;
7. Market size – World starch market is estimated to reach 75M tonnes in 2015 [40]. Potato starch constitutes 6% of world production, hence 4.5 tonnes in 2015. Like pectin, small quantities of potato starch in an application produce the required effect; potato starch is a market with many clients;
8. Market value – Despite potato starch provenience is green and ecological, potato starch itself detains a very low market price (0.39 €/kg) and therefore little added value;
9. Competition – potato starch is commodity products that may not be very differentiated form its competitors. It holds several advantages against its starch competitors, but the last are much more used in the market (maize and corn);
10. Market trend - Organic and green raw source materials is an attractive growing market trend. Potato starch as an ingredient is included in this growing trend.

Paper Residues

The Industry of paper manufacture is one of the most environment pollutants worldwide Industries. They are strictly regulated Industries regarding their effluent residues. Lignin is a wood wall compound that is removed from wood previous to paper manufacture. The pulping and bleaching steps of paper manufacture generate most of the liquid, solid, and gaseous wastes [41]. Pulping is the process in which the raw material is chemically or mechanically treated to remove lignin in order to facilitate cellulose and hemicelluloses fiber separation; such improves the papermaking properties of fibers [42]. Bleaching is a multistage process to whiten and brighten the pulp through removal of residual lignin. Pulping and bleaching operations are energy intensive and typically consume huge volumes of fresh water and large quantities of chemicals such as sodium hydroxide, sodium carbonate, sodium sulphide, bisulphites, elemental chlorine or chlorine dioxide, calcium oxide, hydrochloric acid, etc. [43]. The effluents generated by the mills are associated with the following major problems:

→ Dark brown coloration of the receiving water body. This results in reduced penetration of light, thereby affecting benthic growth and habitat. The brown color is due to lignin and its degradation products;

→ High concentration of organic matter which contributes to the biological oxygen demand and depletion of dissolved oxygen in the receiving ecosystems;

→ Presence of persistent, bio-accumulative and toxic pollutants.

Paper Industries spend a lot of money in several fluent treatment processes to assure that wastes do not reach the environment. Therefore, there is a problem and need that can be solved by subcritical water extraction technology. The technology is able to hydrolyze lignin into a bio-oil providing a cheap and environmental safe procedure opposed to the current treatment process. A carbonaceous bio-oil is the result of hydrothermal polymeric structure break-down into smaller intermediate species, which can react and produce a mixture of smaller hydrocarbon molecules, lipids and gases [44]. Hydrolysis of lignin with the technology in study has been previously reported [45]. Being lignin an unwanted and treatment expensive residue, it is believed that its purchase cost would be small.

The resultant bio-oil product and possible market application for lignin can be considered a market trend because it provides electricity and heat from an environmental pollutant [44]. However, in Portugal Paper manufacture industries already employ a solution to obtain energy from their wastes. Portucel (Portuguese group of Paper Industries) for example, owns two thermoelectric stations with capacity to produce 12.5 MW through combustion of biomass; and combined natural gas co-generation plant. It is quite a challenge to try and replace long implemented treatment processes in such big companies as Paper Industries.

The bio-oil from lignin residues market option was analysed as follows by table 3.2 criteria:

1. <u>Cost of waste treatment</u> – Lignin residues must be treated and its cost is assumed to be considerable given that it involves specialised separation technologies. Prices per one liter of fuel range 1.7€ (retail price) in Portugal. Lignin resultant bio-oil would cost likewise to be able to compete in the energy fuel market. In spite of high quantity of lignin residues available, BioADD considers this criterion to be scored with zero because productivity is very low. That is, the possible high quantity of lignin residues does not compensate the final market price;
2. <u>Availability</u> – lignin availability is compromised because it is already used by paper manufacture Industries as source of energy;
3. <u>Geographical location</u> – the residue can be sought in the specific places like Paper Industries;
4. <u>Environmental sustainability</u> – lignin residues are a severe environment danger as explained above;

5. Legal sustainability – due to the environment threats that lignin residues present, Paper Industries are forced by legislation to treat their residues accordingly. This is an opportunity for BioADD to present a less expensive solution and treat these residues;
6. Price – Despite the growing need for alternative energy fuel sources, this market has a low market price for fuels. The price is located around 1.7€ per liter in Portugal;
7. Market size – bio-oil from lignin residues possibly has a huge number of consumers. This is because it can be used as a bio fuel to power cars, plains, etc. and this market will suffer a high growth given the necessity of humanity to adopt green energy sources; also, because the bio-oil can be combusted to produce electricity or coupled with a CPU unit to also produce electricity and heat;
8. Market Value – this criterion is attributed with the lowest score because probably the perceived price by customers will not be enough to cover the cost of production. Bio-oil does not appear to b a very valuable added product;
9. Competition – the product can be differentiated from its fuel competitors, however this is a very competitive market with major players. Hence, the attributed score is zero;
10. Market trend – Climate changes are the reflection of excess use of natural resources and energy; it constitutes one of the greatest challenges of humanity. Search for alternative energetic sources is a market with potential high growth in the near future. Hence, the classification attributed to this criterion is high.

Urban Solid Residues

Urban solid residues are constituted by several types of plastic and organic materials. They are processed by Urban Residues Treatment Stations and dispatched to landfills or composting, respectively. Both materials can be hydrolysed by subcritical water technology to obtain a bio-oil product [46]. The bio-oil can be sold by itself since it possesses heating power, or can be coupled with a CHP unit to provide electricity and heat. Urban solid residues represent a problem for the environment because there is a need for alternative solution to handle plastics. Plastics can take centuries to degrade and until then they accumulate in the environment [47]. Currently, plastics are combusted and the resultant ashes deposited in landfills or recycled. Landfills are a medium time solution because they represent a growing environmental problem and combustion releases toxic gases into the environment [47]. Recycling seems to be the best alternative available.

Nowadays there is a high consumption pattern whose consequence is increased production of wastes and use of natural resources and energy. Urban plastic residues represent a large volume of residues. In 2005 Portugal produced 45M tonnes of urban solid residues, around 450 kg/hab [47]. They constitute a problem. Utilization of Subcritical Water technologies in Urban Residues Treatment Stations may reduce this waste impact. It is an innovative process because there is no treatment process in these facilities using the same technological conditions as SW Technology. However, as seen in the previous chapter, the subcritical water extraction technology has been applied in the HTU process [19] before.

Considering the market application, electricity from alternative green sources is a market trend with future prospects given the difficulties with current fossil and green technologies. It is therefore a market need. However, this application would face severe competition from major energy players as well as complications in entering an energy distribution channel.

The bio-oil from urban solid residues market option was analysed as follows by table 3.2 criteria:

1. Price – Like the bio-oil product obtained from lignin residues, the one obtained from urban solid residues theoretically detains the same energetic fuel characteristics. Therefore, its price in the market would be near 1.7€ per liter;
2. Availability – urban solid residues represent a huge quantity of wastes. It is assumed that they are moderately available because Urban Residues Treatment Stations have specific routes implemented to deal with these residues;
3. Geographical location – the residue is scattered in several locations;
4. Environmental sustainability – Some plastics need hundreds of years to degrade. The fact that there are more and more quantities of it in urban solid residues constitutes an environmental issue;
5. Legal sustainability – there is a legislation to treat urban solid residues. It does not seem to be highly strict and hence it is an opportunity for BioADD;
6. Price – Bio-oil from urban solid residues has the same market price as lignin bio-oil: 1.7€/;
7. Market size – the product bio-oil obtained from urban solid residues has the same market applications as lignin bio-oil; therefore, BioADD expects the market to have many consumers;
8. Market value – is expected to be low given the bio-oil price and low value added application;
9. Competition – competition is high in the energetic fuel market;

10. Market Trend - Search for alternative energetic sources is a market with potential high growth in the near future. Hence, the classification attributed to this criterion is high.

Sewage Sludges

A possibility considered as a potential waste residue is sewage slugdes before entering Wastewater Treatment Stations. Sewage sludges contains compounds of agricultural value (including organic matter, nitrogen, phosphorus and potassium, and to a lesser extent, calcium, sulphur and magnesium), and pollutants which usually consist of heavy metals, organic pollutants and pathogens [48]. Most of these compounds can be converted into a carbonaceous bio-oil through Subcritical Water Extraction technology. Wastewater composition varies not only throughout the seasons but as well as by minute and original pollution load. This is a disadvantage for the technology under analysis because it is a challenge to estimate the proper technical features to obtain bio oil with known properties.

Sludge is usually treated before disposal or recycling in order to reduce its water content, its fermentation propensity or the presence of pathogens. Several treatment processes exist, such as thickening, dewatering, stabilization and disinfection, and thermal drying. The sludge may undergo one or several treatments. Once treated, sludge can be recycled or disposed of using three main routes: recycling to agriculture, incineration or landfill [47]. The technology at study can reduce and almost eliminate these treatments since it can process liquid compounds; also, a pre water content reduction level is not necessary. Despite it, the need is not as obvious as former applications since Wastewater Treatment Stations are firmly implanted with strict rules concerning energy economization and microorganism management; some wastewater treatment facilities obtain commercial products like PHAs (Polyhydroxyalkanoates - biodegradable plastic) through aerobic/anaerobic treatment conditions variations. It is a challenging task to surpass legal directives and compete with these companies for the wastewater sludges. Nonetheless, there is an available commercial project named *SlurryCarb* as mentioned in the previous chapter. It transforms municipal sewage sludge into the bio-oil “E-fuel” [18].

Concerning the bio-oil market product, it detains the same characteristics enumerated in previous applications. The idea is analysed as follows by table 3.2 criteria:

1. Cost of waste treatment – it is assumed that sewage sludges must face expensive treatments like inverse osmosis membrane separation for example; as seen in the

previous bio-oil market applications, bio-oil from sewage sludges will probably have an average market price of 1.7€/l;

2. Availability – sewage sludge waters are treated to remove pathogens, water content and organic compounds. However, they're not used for any specific application that may jeopardize BioADD technology possible application;
3. Geographical location – the residue is located in several disperse places in Portugal.
4. Environmental sustainability – sewage sludge's constitute an environmental issue, specifically concerning waste residue management;
5. Legal sustainability – there's a very strict legislation to treat sewage sludges residues in order to safely and efficiently remove dangerous pathogens and organic compounds;
6. Price – the bio-fuel application will have the previous bio-oils application characteristics, hence the expected price is 1.70€ per liter;
7. Market size – BioADD expects the market to have many consumers for the bio-oil produced from sewage sludges given the similarities of this product to the above two mentioned marker applications;
8. Market value - is expected to be low given the bio-oil price and low value added application;
9. Competition - competition is high in the energetic fuel market;
11. Market trend - Search for alternative energetic sources is a market with potential high growth in the near future. Hence, the classification attributed to this criterion is high.

Hospital Residues

Hospital residues are classified as four types of residues [49]:

i) **Type I** – residues compared to urban solid residues that do not require any special treatment;
ii) **Type II** – Non dangerous hospital residues that are not subjected to any special treatment and can be compared to urban residues;
iii) **Type III** - Biohazard medical wastes. They're contaminated or suspected of and after incineration or other effective treatment, can be handled as urban residues;
iv) **Type IV** – Non specific hospital residues. These residues represent a biohazard and must be incinerated to not endanger public health.

Type III and IV are the most dangerous types of hospitals residues. These residues are collected and sent to an incinerator facility. Resultant ashes are afterwards deposited in landfills. Type III and IV contain biologic material as well as plastics - both able to be processed through subcritical water technology and result in the formation of a bio-oil. There's however materials that cannot be processed like needles and metallic objects. Hospitals must treat type III and IV residues according to the Portuguese legislation due to biological contamination and environmental damage. However, as they cannot treat them inside the Hospital facilities [49], Hospitals pay certain amounts to company whose business core is to treat and inactivate them. Therefore, hospital residues are a problem that can be solved with BioADD technology because it provides a fast, secure, effective and cheaper treatment. For that reason, they are also seen as inexpensive to obtain.

There is the possibility of installing a subcritical water extraction technology reactor inside the Hospital. It presents benefits such as fast and cheaper treatment costs for the Hospital. To pick the hospital residues and transport them into another place would not set the company apart from the already existent that treat and inactivate these residues. Although these companies do not work with the technology in study, they employ processes that achieve high temperature and pressures.

Regarding market application analysis, the bio-oil product faces the same problems in price and market entrance as urban residues raw material and previous bio-oil applications. The possibility of providing heating and electricity for the Hospital instead of placing this power on a national distribution network was considered. It is an interesting consideration. However there is an important issue to be attended that concerns legal aspects. Legislation is strict about hospital residues treatment and it is expected to be difficult to surpass given also the dangers of a supercritical fluid technology placed inside a health institution. If the reactor was outside and away from the Hospital facility, legislation would require bureaucratic applications that can take too much time to be considered than the one BioADD is willing to endure.

The bio-oil from hospital residues market option was analysed as follows by table 3.2 criteria:

1. <u>Cost of waste treatment</u> – it is assumed that productivity will be low because of the fuel oil being priced around 1.7 €/l although there is possibly high quantity of hospital residues available;
2. <u>Availability</u> – hospital residues are available because they are not used for other applications;
3. <u>Geographical location</u> – these residues are dispersed in several locations;

4. Environmental sustainability - the residue represents an environmental issue because hospital residues contain pathogens and materials that have been in contact with dangerous diseases and may endanger public health;
5. Legal sustainability - given the environmental issue, hospital residues face strict treatment legislations;
6. Price – price of the product bio-oil is inserted in the same energetic fuel categories form previous possible market applications: 1.7€ per liter;
7. Market size - BioADD expects the market to have many consumers given the similarities between the above three mentioned market applications;
8. Market value – is expected to be low given the bio-oil price and low value added application;
9. Competition – competition is high in the energetic fuel market;
10. Market trend – Hospital resides for alternative energetic sources is a market with potential high growth in the near future. Hence, the classification attributed to this criterion is high.

Further possible market applications were considered for SW Technology like rubber (tyres) and slaughterhouse residues. However, both market applications is a carbonaceous bio-oil that has been analysed in the above last four applications.

The highest scored applications analysed in table 3.2 are: **i)** Apple & Citrus residues with 14 points, **ii)** Potato wastes with 13 points and **iii)** rice bran with 13 points.

During the market selection, BioADD team attended the event FOOD I&DT (Alimentaria & Horexpo Lisbon 2013). In it, BioADD was approached by the company Campotec. This company business is to process potatoes and apples, as well as other vegetable/fruits. Campotec was looking for a solution to their high quantity of potato wastes considering that they pay 0.03€ per ton of residue placed in landfills. Given this market opportunity and need, BioADD opted to further study the conversion of potato wastes to potato starch over conversion of rice bran residues to phenolic compounds. Regarding the winning market applications, BioADD contacted the company LARA - Laranja do Algarve, to obtain specific residues information and this company was very kind and demonstrated cooperation. In conclusion, pectin and potato starch market applications will be further analysed in the next sub chapter.

3.2 Market Funnel

This subchapter aims to present a detailed analysis and comparison of the pectin and potato starch in order to select the best profitable market application for the BioADD technology.

3.2.1 Pectin Analysis

3.2.1.1 Chemical Composition

Pectin is composed of an acidic hetero-polysaccharide and several types of neutral sugars. It is stable under acidic conditions and degrades under neutral or slightly alkaline conditions [32]. The main chain consists of *α*-1,4-linked *D*-galacturonic acid which is partly methyl esterified [8]. Figure 3.3 shows the composition of the galacturonic acid. The acid groups may either be free, combined as a methyl ester, or with sodium, potassium, calcium, ammonium or amidated salts [11].

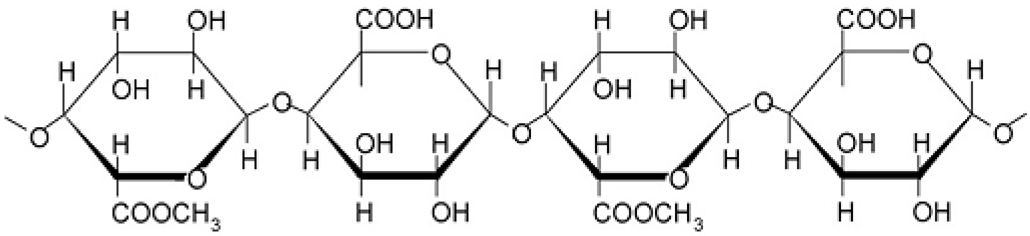

Figure 3.0.3 - Pectin main chain polysaccharide structure composed of *α*-1,4-linked *D*-galacturonic acid monomers

Pectin is resultant from the protopectin form plant structure. Protopectin is mainly present in the middle lamella of plant cells, in primary and secondary cell walls [5,6]. It is an insoluble complex structure that gives shape, strength and support to the soft non-woody parts of the plant and unripe fruits [4,5]. Protopectin is widely distributed in all plants and contributes to its tissue rigidity, permeability and water holding capacity [51]. It is thought that protopectin combines either with cellulose in plant tissues to form an insoluble macromolecule or with Ca^{2+} or Mag^{2+} ions to form insoluble salts called pectinates [21]. In the form of protopectin, the structure contains blocks of homogalacturonic acid ("smooth regions") and blocks of neutral sugars molecules (rhamnose, galactose, arabinose) in a highly branched structure ("hairy regions") [4,6]; Ueno and collaborators [21] proposed a structure of protopectin shown in figure 3.4. When pectin is extracted, most of the hairy region is destroyed leaving mainly the smooth regions of galacturonic acid with some neutral sugars units attached in the main chain [11]; the proportion of hairy and smooth regions varies with the source plant material.

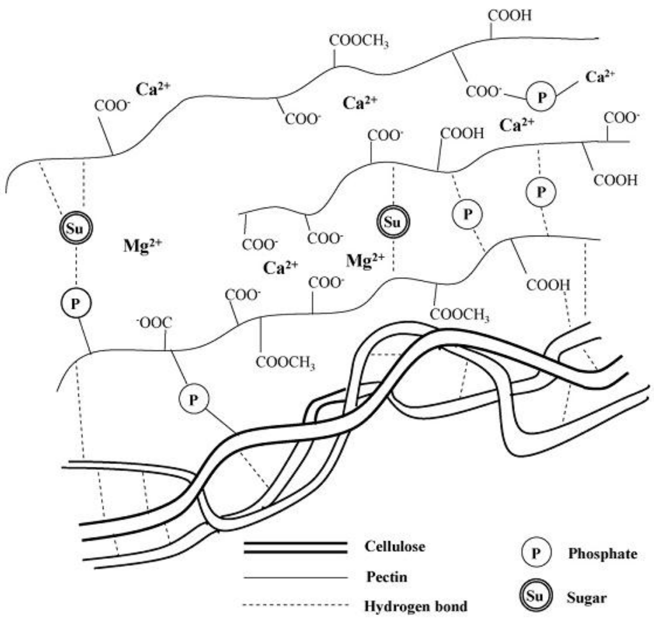

Figure 3.0.4 - Hypothetic structure of protopectin in plants

Pectin is a hydrocolloid substance [52]. A hydrocolloid is defined as a colloidal system in which the colloid particles are disperse in water [53]. A hydrocolloid has colloid particles spread throughout the water and depending on the quantity of water available, that system can be a gel or a liquid. They allow improvement of body and mouthful of beverages, improvement or texture modification, pouring properties and cling in a range of food products [52]. When water is added to dry powdered pectin, it becomes hydrated and swells to form a gelatinous mass [50].

Pectin's ability to jellify is dependent on its methoxyl group content [54]. All sugar structural components of pectin (arabinose, galactose, rhamnose and galacturonic acid) have free hydroxyl groups (-OH) that can be methylated to form methoxyl groups ($-OCH_3$) (methylation) [52,55,56] (figure 3.5). The methoxyl content varies according to the degree of methylation and hence Pectin is classified according to High Ester, Low Ester and Amidated Pectin.

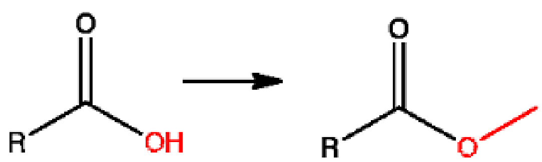

Figure 3.0.5 - Methyl esterification reaction. A methyl group (CH_3) replaces the hydrogen on the OH group of the carboxylic acid, changing the R group from COOH to $COOCH_3$

<u>High Methylated Ester Pectins</u>

HM (High Methylated) Pectins have this classification if they possess more than 50% of esterified polygalacturonic acid units content [57]. Gel strength depends on acid content, type of pectin and soluble solids content. HM Pectins form gels if the pH is below 3.6 and a co-sulute is present, typically sucrose at a concentration higher than 55% by weight [31]. The degree of esterification correlates with the gel setting rate (the time required to form a gel) and texture. HM Pectins form more brittle and elastics gels at high temperatures, as well as jellify quicker than LM Pectins [32]. The following figure 3.6 presents the structure of HM Pectin [11]:

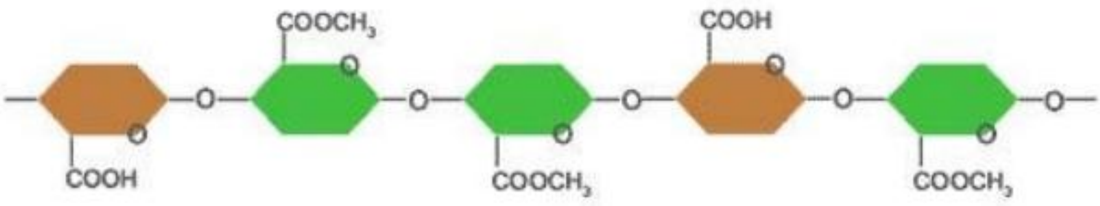

Figure 3.0.6 - High Methylated Pectin structure

Low Methylated Ester pectins

LM Pectins are pectins with less than 50% of esterified galacturonic acid units content. These pectins form gels with sugar and acids, as well as with calcium ions if they have lower soluble content [57]. The gel strength depends on the pectin concentration, type of pectin, soluble content, pH range and concentration of buffer salts and calcium ions [57]. Syneresis (loss of water from the gel) will occur if the calcium ion concentration is exceeded and may lead to formation of calcium-pectinate, the insoluble salt of pectin [57]. Gel settling with LM Pectins is also possible with low solids content and at a high pH-value [57]. LM Pectins are obtained from HM Pectins through continuous use of acid extraction in the conventional method or through de-esterification [11, 12]. The following figure 3.7 presents the structure of LM Pectin [11] with occasional -CH_3 functional groups attached:

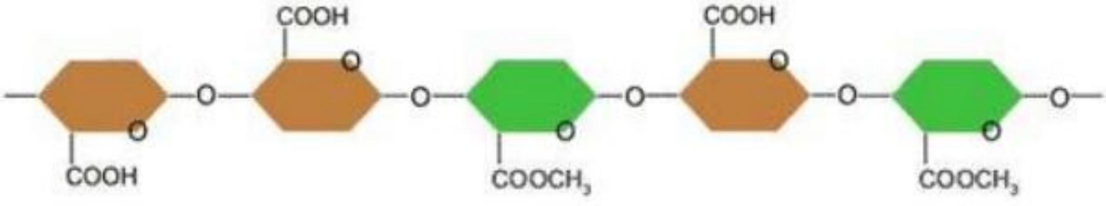

Figure 3.0.7 - Low Methylated Pectin

The acid groups of pectin react with calcium ions which have two positive charges. The last can link two acid anion groups with negative charges. If enough negative groups occur together, as in LM Pectins, calcium ions can link pectin molecules together in a gel network in the absence of high sugar levels [4,11]. This LM Pectin gel formation is named egg box and its structure is represented in figure 3.8.

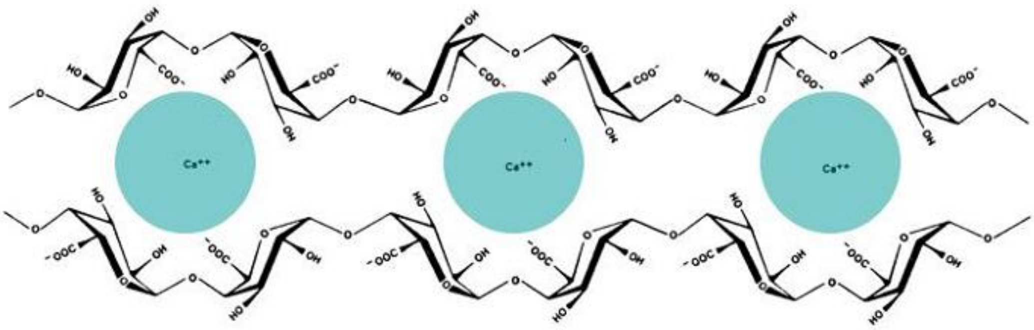

Figure 3.0.8 - Low Methylated pectin Eggbox gel formation model: free galacturonic acid chains are gathered to form a leg by binding to calcium ions

Amidated Pectin

Amidated Pectin is obtained through the use of ammonia to replace part of the ester groups from LM Pectin into amide groups. This process modifies gelling properties in comparison to acid de-esterified pectins [57]. LM Amidated pectins also require the presence of calcium ions to jellify and will set with only a minimum of calcium ion concentration as compared to LM Pectins [57]. Also, the gel settling temperature is less influenced by the calcium dosage [57] and it is thermally reversible [55]. The following figure 3.9 presents the structure of Amidated Pectin [11] with occasional -NH_3 functional groups attached:

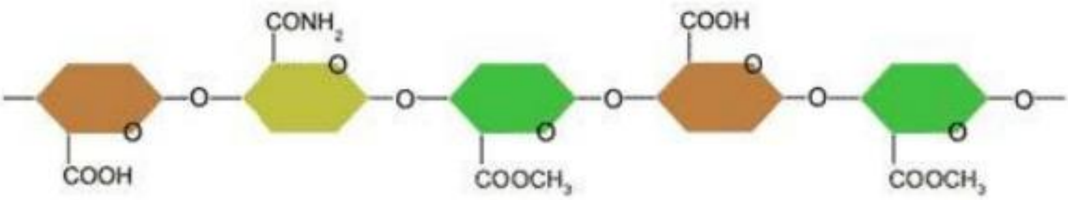

Figure 3.0.9 - Amidated pectin structure

Pectin Properties

Pectin detains several market applications due to its properties, which are interlinked between each other. Pectin provides structure, flow, stability and eating qualities as desired by consumers. Pectin is characterized by the following properties [59]:

- Gelling (Chemistry of Pectin and Its Pharmaceutical Uses)
- Thickener
- Stabilizer

- Texturizer (May, sugar beet pectin)

Pectin is added to processing of fruits such as strawberry and other industrially processed foods, particularly the types of foods which do not contain gelatinous substances or any other stabilising ingredient [60]. Pectin will maintain their structure as well as their physical properties during the processing period.

→ Gelling

A gelling agent gives structure and shape to substances. Some thickening agents are gelling agents, forming a gel, dissolving in the liquid phase as a colloid mixture that forms a weakly cohesive internal structure [60].

Formation of a gel is the formation of a tri-dimensional structure that entraps liquids and solutes inside. Pectin swells forming a tridimensional structure upon contact with water, for example. Types of pectin jellify differently:

- **HM pectins**: Due to the presence of sugar and consequent reduction in electrostatic repulsion and hydrogen bonding between undissociated carboxyl and secondary alcohol groups, HM pectin chains associate forming a two dimensional solid network [61]. Liquid and solutes become immobilized inside the structure [62]. The high sugar concentration reduces the water activity of the system and the pectin molecules become dehydrated and form bong zones more easily. That is, the reduction of electrostatic repulsion decreases polymer-water interaction leading to junction zone stabilization by promoting hydrophobic interactions between ester methyl groups [61]. Formation of stabilizations zones transforms the two dimensional structure into three dimensional. This results in a system resisting deformation and showing a stress-strain relationship for small deformation.
- **LM Pectins** form a gel in the presence of Ca^{2+} ions, over a wider range of pH values. Calcium ions act as a bridge between pairs of carboxyl groups of different pectin molecules. The pH is higher than HM pectins because only dissociated carboxylic groups take part in the ionic cross linkage [31,61]. Calcium ions concentration must be regulated because excess of it can destroy the gel by increasing the cross-linking to such an extent that pectin is precipitated. LM pectins can also form a gel in the presence of low calcium concentrations due to the combined effect of pH and sugar content in water activity and hydrophobic effects [55]. The gel forming ability of LM pectins increases with decreasing degree of methylation [62].

The gel setting time for high ester pectins is longer than that for pectin products of low esterification degree [10, 12]. As the content in methyl groups increases, so does the spreading quality [54].

Requirements of the costumer depend very much on their processing conditions. HM, LM or Amidated pectin can be used in Jams and jellies manufacture. For example, jams with high sugar made with HM pectins can resist baking and can be used in jam tarts. In another hand, suitable formulations using amidated low methoxyl pectins will be thermally reversible -- they will melt and reset to a good gel on cooling [32]. Dietetic and low calorie jams use Amidated pectin but can also use the other two. Glazes and pastries that are pasty but stable with more than 65% sugar solids can be diluted and melted, to reset to its clear shiny glaze if Amidated pectin is used [32].

→ Thickener

When applied to substances, thickeners increase the viscosity of a solution or liquid/solid mixture without substantially modifying its other properties. When added to food, it will increase its viscosity but also provide specific functionality to the product [63]. Thickeners are also used in paints, inks and explosives, for example. They are most frequently applied to foods where the target property is taste. Thickeners may also improve the suspension of other ingredients or emulsions which increases the stability of the product [60].

There are several thickeners available from natural sources and pectin is one of them. Addition of small quantities of pectin to a liquid or liquid/solid mixture is able to result in the desired thickness for the producer.

→ Stability

The role of a stabiliser is to maintain the integrity of foods in terms of physical and textural attributes, particularly during heat treatment of foods, transport or storage [60]. As a thickener, pectin also improves the suspension of other ingredients or emulsions which increase the stability of the product. Pectin plays a stabilization role in certain food such as acid milk drinks, where it stabilizes the milk proteins under acidic conditions, or in ice creams, where it prevents the appearance of large ice crystals or lumps that would make the ice cream feel gritty [11,32].

→ Texturizer

Texture is a sensory feature sensed by consumers [64]. It can be described as the feeling of a substance as it is perceived in the mouth. Texture acts in the success of the product because it is an indicator of the freshness and stability of it [64]. Pectin is used in drinks, sauces, syrups and some foods to make a desirable texture [65]. For example, besides acting as a thickener, HM pectin is added to fruit preparations to be used in yoghurts to provide *mouthfeel* (taste of food) to the final product [32].

3.2.1.2 Pectin Market Applications

Pectin is a naturally occurring biopolymer that is finding increasing applications in the pharmaceutical and biotechnology industry. It has been used successfully for many decades in the food and beverage industry as a thickening agent, a gelling agent and a colloidal stabiliser. Industrial production started in the 20th decade of last century [32]. Pectin also has several unique structural properties that have enabled it to be used as a matrix for the entrapment and/or delivery of a variety of drugs, proteins and cells [66].

According to CP Kelco [67], worldwide consumed pectin derived mainly from orange (85.5%), followed by apple (14%) and sugar beet (0.5%) plant sources (figure 3.10) in 2004. Information about the total amount of consumed pectin is not available.

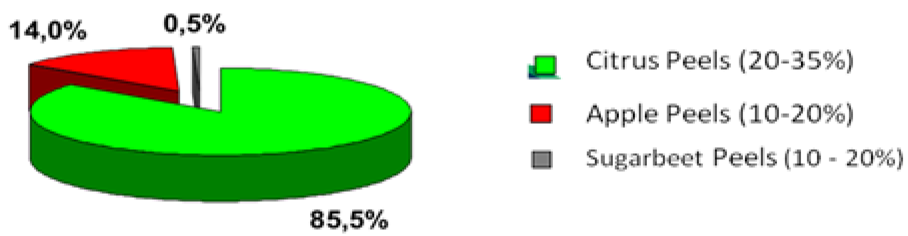

Figure 3.0.10 - Worldwide consumed pectin source in 2004

Pectin is broadly used in jams, acidified milk drinks, bakery, yoghurt fruit preparations, fruit beverages, confectionary and soft drinks. Besides its application in the food market, pectin can also be used in pharmaceuticals (sliming and cosmetic pharmaceuticals) and tobacco (as glue) Industries [67] (figure 3.11).

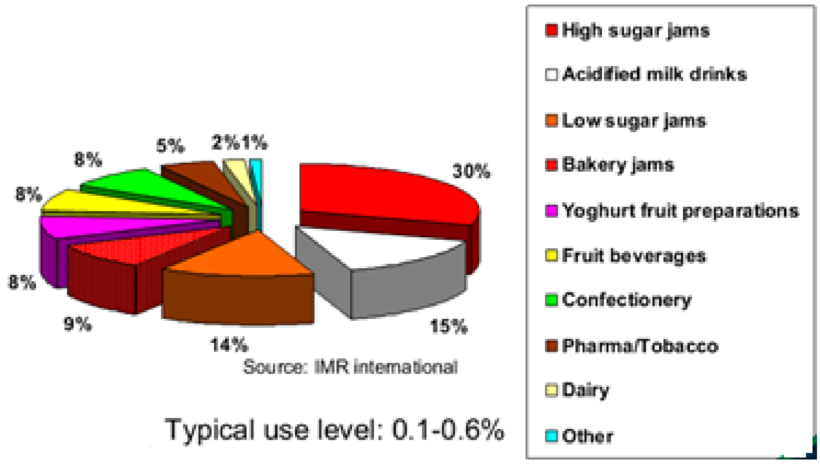

Figure 3.0.11 - Pectin applications estimated in 2004

The three types of pectin available (HM, LM and Amidated) are used in the market to perform specific food requirements given by pectin properties: thickener, stabilizer, gelling and texturizer agent. Such manufacture requirements include pH range, methylation degree, acetylating degree, viscosity, galacturonic content, molecular weight, etc [54].

Due to its chemical composition or/and gelling properties, pectin has been employed in the pharmaceutical Industry, health promotion (slimming products) and treatment. It has been used as a carrier for drug delivery to the gastrointestinal tract, such as matrix tablets, gel beads and film-coated dose form [66,68].

In the pharmaceutical industry, pectin favourably influences cholesterol levels in blood for example. It was reported and studied that consumption of at least 6 g/day of pectin is necessary to have a significant effect in cholesterol reduction [66]. Pectin is used in mixture for diarrhoea together with kaolin and sometimes bismuth compounds [32]. Pectin also acts as a natural prophylactic compound against poisoning by toxic cations because it was demonstrated its effectiveness in removing lead and mercury from the gastrointestinal and respiratory organs [68]. Also, pectin has been used to maintain the viscosity of some syrups [32].

In presence of water, pectin swells and increases the viscosity of cosmetics and personal care products [69]. It gives a better performance and a substantial feel to those products. It is safe and non irritating to the skin. Pectin can be used in facial moisturizers, facial cleansers, sunscreen products, anti-aging treatments, makeup foundations, shampoos, hair conditioners and hair styling products. Pectin plays a role of emulsion stabilizer to hell keep oil and water ingredients stable in solution [69].

BioADD considered the hypothesis of selling pectin to the pharmaceutical or cosmetics Industry. However, information about both markets is scarce and of difficult access. Also, several contacts were attempted but there were very little returns. Due to the lack of solid information, both Industries as pectin consumers were abandoned.

Upon contacting Herbstreight & Fox Company, the following information was kindly provided by Dr. Hans Ulrich: "*the main applications for pectin are in food. Pharmaceuticals and cosmetic products with pectin do almost not exist. You can search in the internet and you will find some exotic products in a niche of "all nature" claims. Pharmaceuticals and cosmetic products are not a sufficient base for pectin. Especially cosmetics often have a skin friendly neutral pH (beside AHA crèmes) but pectins are not stable in neutral pH conditions. In pharmaceuticals and food supplements we have the cholesterol and blood glucose claim from EFSA. Slimming products and detoxification formulations come and go but are an instable segment*".

The three types of pectin can be used in several market applications. Each specific application requires a type of pectin that with very slight changes in its chemical composition can be used for another entirely different application. Each application requires individual chemical formulation regarding the desired product features. BioADD technology holds the potential to produce pectin and introduce slight different chemical changes in order to produce pectins according to the consumer and market needs. BioADD can produce PectiCitrus to fulfil HM, LM and Amidated requirements. Nevertheless, the first BioADD market product – PectiCitrus – is High Methylated pectin and hence it is reasonable to first enter the markets where this sort of citrus pectins is used. Table 3.5 presents several food applications where citrus and apple HM, LM and Amidated pectins are used [57]:

Table 3.3 – Food applications for citrus and apple HM, LM and Amidated pectin

	HM Pectin		**LM Pectin**		**Amidated Pectin**	
Application	**Citrus Pectin**	**Apple Pectin**	**Citrus Pectin**	**Apple Pectin**	**Citrus Pectin**	**Apple Pectin**
	Galacturonic acid content (%)					
Jams, marmalades, low calorie fruit preparations and fruit spread (pH 2.9-3.3, TSS ≥ 58%)	**> 70%**	-	-	-	-	-
Jams, marmalades and fruit preparations (pH 3.0-3.3, TSS ≥ 55%)	**51 – 70 %**	> 77%	-	-	-	-
Dietetic Jams and Marmalades (pH 2.8-3.2, TSS > 58%	-	> 77%	-	-	-	-
Jams and marmalades filled in glass jars or large-size containers	-	54 – 64 %	-	-	-	-
Fruit preparations and fruit	-	54 – 64 %	-	-	-	-

spreads sweetened with concentrate (pH 2.8-3.2)						
	HM Pectin		LM Pectin		Amidated Pectin	
Application	**Citrus Pectin**	**Apple Pectin**	**Citrus Pectin**	**Apple Pectin**	**Citrus Pectin**	**Apple Pectin**
	Galacturonic acid content (%)					
Jams, marmalades and jellies (pH 2.8-3.2, TSS < 55%)	-	-	-	48 – 58%	-	-
Dietetic jams, marmalades and jellies (pH 3.0 – 3.4) Low Calorie jams and fruit preparations (pH 3.0 - 3.4, TSS < 55%) Fruit purées (pH 3.3 – 3.0, TSS 15-25%) Fruit toppings (pH 3.0 – 3.8, TSS < 55%)	-	-		29 - 44%	-	-
Low calorie jams, marmalades, fruit preparations and fruit spreads (ph 3.0-3.5, TSS 30-55%)	-	-	-	-	-	28-36%
Low calorie jams, marmalades, fruit preparations and fruit spreads (pH 3.0-4.0, TSS 10-40%)	-	-	-	-	-	27-32%
Low calorie jams, fruit spreads and jellies (pH 3.0-3.6, TSS 10-40%))	-	-	32– 45%	-	-	-
Low calorie jams, fruit spreads and jams (pH 3.0-3.5, TSS 30-55%)	-	-	-	-	30-46%	-
Low calorie jams, fruit spreads and jams (pH 3.0-4.0, TSS 15-45%)	-	-	-	-	23-32%	-
Baking stable fruit preparations (pH 2.9 – 3.2, TSS ≥ 60 %)	-	59- 64%	-	-	-	-
Baking stable fruit preparations (pH 3.0 – 3.8, TSS 50-80%)	-	-	-	35-42%	-	-
Fruit fillings for baked products (pH 3.0 – 3.8, TSS 40-72%)	-	-	-	36-44%	-	-
Fruit jellies, jelly fillings, domino ginger (pH 2.8 – 3.4, TSS 68 - 80%)	-	55- 61%	-	-	-	-
Bread jellies (pH 2.8 – 3.4, TSS 68 - 80%)	-	58- 65%	-	-	-	-
Fruit jellies, Jelly fillings (pH 3.0-3.6, TSS 68- 80%)	**55 – 65%**	-	-	-	-	-
Fruit jellies, jelly fillings, pastilles (pH 3.0-3.6, TSS 68-85%)	-	-	-	-	51-59%	-
Fruit preparations for Yoghurts (pH 3.2 – 4.2, TSS 45-65%)	-	52- 57%	-	-	-	-
Fruit preparations for Yoghurts (pH 3.5 – 4.2, TSS 30 - 45 %)	-	-	-	41- 48%	-	-

	HM Pectin		LM Pectin		Amidated Pectin	
Application	**Citrus Pectin**	**Apple Pectin**	**Citrus Pectin**	**Apple Pectin**	**Citrus Pectin**	**Apple Pectin**
	Galacturonic acid content (%)					
Fruit preparations for Yoghurts (pH 3.5 – 4.2, TSS 30 - 50%)	**66 – 72%**	-	-	-	-	-
Fruit preparations for Yoghurts (pH 3.5 – 4.5, TSS 10-60%)	-	-	-	-	14-25%	-
Fruit preparations for Yoghurts (pH 3.5 – 4.5, TSS 30-65%)	-	-	-	-	-	41-57%
Stabilization of fermented milk drinks (pH .6 – 4.2)	-	72-78%	-	-	-	-
Stabilization of fermented milk drinks (pH .6 – 4.2)	**> 68%**	-	-	-	-	-
Yoghurt and fresh cheese with creamy structure (pH 3.9 -4.2) Fruit-milk desserts jellification by mixing with cold milk Semi-finished products for milk shakes	-	-	-	38-44%	-	-
Fruit preparations for yoghurts, preferred in fermented products	-	-	-	-	23-36%	-
Stabilizing turbidity in soft drinks (pH 2.7 – 4.5) Water Ice sherbets	**68 – 76%**	-	-	-	-	-
Stabilizing turbidity in soft drinks (pH 2.7 – 4.5) Water Ice sherbets	-	70–76%	-	-	-	-
Fat reduced margarine (40-60% fat reduce), crème fraîche, salad creme	**68-76%**	-	-	-	-	-
Ketchup, sauces and chutneys (pH 3.0-3.8)	-	-	-	-	30-36%	-
Turkish delight (pH 3.5-5.5, TSS 70-85%)	-	-	-	-	16-24%	-
Classic cake glazings (pH 3.3-3.8, TSS 62-67%)	-		-		27-32%	-
Cake glazing for cold use (pH 3.1-3.7, TSS 60-65%)	-	-	-	-	30-36%	-

Source: Herbstreigh & Fox
Notes: Acid galacturonic content is represented by %, TSS represents the solids soluble content

The conclusion of table 3.5 is that it provides the necessary information to select the correct food applications for PectiCitrus. Citrus fruit has more quantity of pectin in its peels (30%) than apple (15%), therefore apple as a raw material will not be used by BioADD. The following markets can use PectiCitrus in its applications:

- Jams, marmalades, low calorie fruit preparations and fruit spread
- Jelly fillings

- Fruit preparations for yoghurts
- Stabilization of fermented milk drinks
- Stabilization of turbidity in soft drinks
- Water ice sherbets
- Fat reduced margarine, crème fraîche, salad crème

These applications can be gathered under five major market categories:

1. Jams, jellies and marmalades,
2. Yoghurts and fermented milk drinks
3. Soft Drinks
4. Ice creams
5. Sauces

Jams, jellies and marmalades are made from fruits or fruit juices, sugar, edible acids and pectin as a gelling agent. Pectin gives the jelly-like consistency to jams, otherwise they would be sweet juices [68]. In some markets, pectin is available as a powder to be used in home jam making. In Portugal there is available the product Pectigel from the brand Diese. Conventional jams and marmalades which contain above 60% sugar and soluble fruit solids, high-ester pectin are used. Not all jams and jellies require the same amount of pectin because of the fruit source. The quantity required varies from 0.2 to 0.4% and is dependent on the original fruit proportion of pectin [32]. For example, apple jam requires less quantity of pectin than strawberry jam.

Dairy products are described as an acidified protein liquid system with stability and viscosity similar to milk and exist in many variations like yogurt drinks, soy milk, fruit milk drinks, butter-milk, etc [11,13]. These drinks are composed of an acid dairy phase (fermented base) or neutral phase (milk, soy-milk, etc) with an acidic medium (fruit phase like pulp, fruit concentrate, etc) that can be flavored. Addition of HM Pectin to acid milk drinks helps to prevent the formation of sediment. Casein in milk is normally at pH 6.6 in the form of stable micelles. When pH of milk drops to 5.5 – 5.8, casein particles form clusters (submicelles); Lowering more the pH to 5 – 5.5 range leads to reorganization of the casein structure into a multi-strand association instead of spherical as calcium becomes soluble. Further lowering of pH below 5 the calcium is soluble and the aggregation of casein is irreversible, forming a three-dimensional network constituted by the cluster of aggregated strands [11, 13, 14]. HM Pectins are more efficient in stabilizing acid dairy drinks because pectin coats casein protein particles reducing the electrostatic bonding [11,13]. Best stabilization occurs at 3.8-4.2 pH range and depends on particle quantity, particle size and viscosity [71]. Pectin will provide a smooth and creamy structure and a fruit specific flavor to fruit preparations for yoghurts; it also helps in obtaining a regular distribution of the fruit particles and achieving a smooth surface [57]. In products combined fruit preparations and yoghurts, pectin provides a stabilization effect and keeps the fruit preparation separated from the yoghurt [57].

Pectins are increasingly becoming more used in soft drinks due to their carbohydrate nature, low calorie and turbidity stabilization as well as increasing viscosity properties [57]. Low calorie soft drinks can be thin and lack the *mouthfeel* provided by sugar in conventional soft drinks. To improve the texture of such products low levels of pectin are added [32].

Pectin is used in ice creams to improve the texture, prevent ice crystals formation and help to remain creamy for longer periods of time [31,56]. Also, addition of pectin provides an increased viscosity of the mix, enables formation and stabilisation of a homogeneous micro foam structure as well as the formation of finely dispersed, homogeneously small ice crystals. The result is a product with smooth, high *mouthfeeling* and great melting behaviour [73].

3.2.1.3 Potential Production

Potential production of a company is the highest level of production that that company can achieve in determined environmental conditions. Regarding BioADD, this concept is applied to the Portuguese potential pectin production with BioADD Technology.

Because PectiCitrus is extracted from orange peels, it is possible to esteem *the company* maximum production potential considering the total orange peels productions in Portugal. An orange contains around 21% in weight of waste peels. Therefore, 21% of the total orange production in Portugal will be considered. This value is derived from the weight measure of a small orange (table 3.6).

Table 3.4 – Orange weight measurement

	Weight (g)
Total	118.44
Peel	24.25
Pectin	7.28
Peel percentage	20.47 %
Pectin percentage	6.13 %

Notes: the weight of a small orange was measured. Peels constitute about 21% in relation to an orange. Pectin averages about 30% of the orange peel weight, therefore it is esteemed in 6% of the total orange.

Data gathered in Statistical Yearbook of Algarve Region [74] demonstrates that Algarve is the major Portuguese citrus fruit regional producer, detaining 89% of it. According to the same study, in 2011 Portugal produced 263 thousand tons of citrus [74] (table 3.7).

Table 3.5 – Citrus fruit production in Portugal (2011)

	Algarve (ton)	Portugal (ton)	Peel wastes (ton)
Oranges	185 456	228 101	47901
Tangerines	28 913	33 000	6930
Lemons	6408	828	174
Pomelo	13 132	1185	249
Total citrus fruit	233 909	263 114	55 254

Source: INE 2011
Notes: Quantity of peels represents 21% of the Portugal citrus production in Portugal.

To esteem pectin potential production with BioADD Technology, two criteria are taken into consideration: **i)** BioADD technology extraction efficiency: 75% based on previous literature findings [33] and **ii)** the amount of pectin in citrus fruit peels: 30%. It is then possible to obtain 11 thousand tons of pectin from all the citrus peels produced in Portugal (table 3.8), representing 110 M€ market value. The market value was calculated through the information provided by Dr. Hans-Ulrich Endress (Secretary General of IPPA) that pectin market PVP is 10€/kg. Internet research evidenced that pectin PVP ranges 6€ to 15€ per kg, therefore the information provided by Dr. Hans-Ulrich is a medium value considered hence-forth in this thesis.

Table 3.6 –Portuguese pectin potential production in 2011 from citrus fruits, through BioADD technology

	Citrus fruit
Total production (tons)	263,114
Total of peels (tons)	55,254
Total of pectin in peels (ton)	16,576
BioADD Technology pectin extraction (ton)	**11,063**
BioADD Technology Pectin extraction market (M€)	**110.63**

Source: INE 2011

Notes: Values were esteemed according to the following: the amount of pectin in citrus peels averages 30%; BioADD technology is able to extract 75% of the pectin from citrus peels and pectin market was esteemed considering the pectin PVP of 10€/kg multiplied by the total market in tons.

Nevertheless, such production is a potential one and also an extrapolation since it is not possible to process all citrus fruit peels produced in Portugal. A more reasonable potential approximation can be achieved considering the information provided by the company Lara regarding their waste orange peels residues. Dr. Paulo Duque indicated that Lara Company produces from 8000 to 10000 tons of pressed (dehydrated) citrus peel residues. Given this, it is possible to esteem BioADD potential production using Lara citrus peels wastes (table 3.9).

Tabela 3.7 – Pectin potential production from citrus peels in partnership with Lara Company, through BioADD technology

Orange peels wastes per year (ton)	8000
Total of pectin in peels (tons)	2400
BioADD Technology pectin extraction (ton)	**1800**
BioADD Technology Pectin extraction market (M€/ton)	**18**

Source: information provided by Paulo Duque, Lara Company
Notes: Values were esteemed according to the following: the amount of pectin in citrus peels averages 30%; BioADD technology is able to extract 75% of the pectin from citrus peels and pectin market was esteemed considering the pectin PVP of 10€/kg multiplied by the total market in tons

The above table 3.9 concludes that BioADD can potentially produce about 1800 tons of pectin per year using Lara company citrus peels residues. It represents a market of 18 M€ and 16% of the Portuguese potential production estimated in table 3.8. These values were achieved considering once more the BioADD 75% efficiency extraction technology and the fact that citrus peels contains around 30% of pectin.

3.2.2 Potato Starch Analysis

3.2.2.1 Chemical Composition

Starch is present in a wide variety of agricultural and staple food wastes such as potatoes, corn, rice, wheat and cassava. It exists in the form of intracellular granules inside plant tissues. Starch is composed of 1,4–α-linked glucosyl units in the form of linear, water insoluble amylose (20-25%) and 1,6-α-linked branched, water soluble amylopectin (75-80%) [39,75]. Both polymers are represented in figure 3.12.

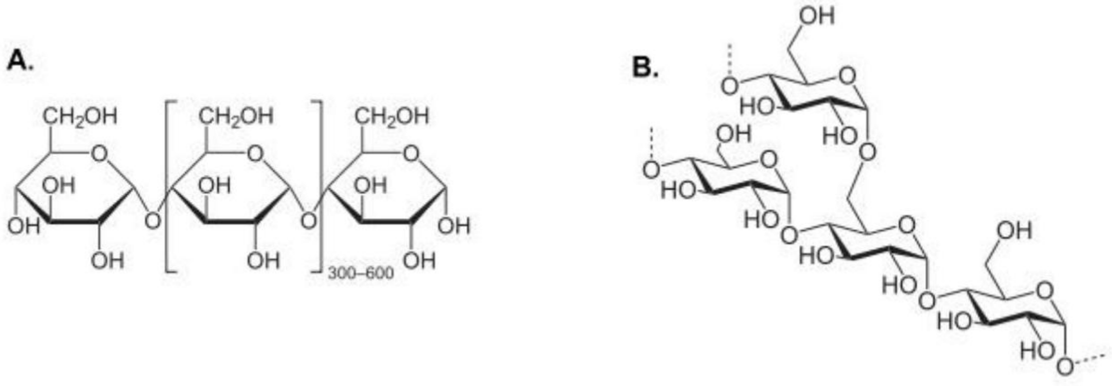

Figure 3.0.12 - Projection of different links between glucose units in amylose and amylopectin. (A) Amylose linear structure composed of 1,4–α-linked glucosyl units. (B) Amylopectin branched structure composed of 1,6-α-linked glucosyl units.

Starch is one of the major polysaccharides used for energy store and is widely distributed in seeds, roots and tubers as well as in leaves and fruits [34]. Potato starch is a good texturizer and regulator in food systems [34]. It is used as a thickening, stabilizer and gelling agent [76]. Potato starch shares these properties with pectin given that it is also a food additive and hydrocolloid. Starch also contributes to the viscosity, adhesion, moisture retention and product homogeneity [77].

Starch can be produced from several plant sources. The industrial most important ones are maize (70%), wheat, cassava (10%), sweet potato (8%) and potato/others (6%) [40].

Starches from different sources vary in viscosifying and taste properties. Starches form tapioca and native potato detains weak intermolecular bonding and gelatinizes easily to produce a high-viscosity paste that thin rapidly with moderate shear. Potato starch produces clear and viscous paste, which is used in products like cereals, dry soups and cake mixes. Also, potato starch is gluten-free. Tapioca starch produces clear, cohesive pastes that gel slowly over time. Starches from corn, rice and wheat form opaque, gelles pastes that have a slight cereal flavor [77]. Potato starch properties depend on the physical and chemical characteristics of the starch, such as mean granule size, granule size distribution, amylose/amylopectin ratio and mineral content [78].

Because native potato starches form pastes and gels often gummy or rubbery, the functional properties of these starches are improved by chemical modification. Chemical modification of native granular starches by etherification alters potato starch gelatinization, pasting and retrogradation behaviour [34]. This is the difference between native and modified potato starch [77].

Regarding potato starch applications, the next table 3.10 presents several applications by Industry where it is used.

Table 3.8 - Potato starch market applications

Industries/Sector	Applications
Food	• Thickens soups, broth and sauces • Baking powder for cakes • Noodles • Processed meat (sausages) • Cheeses • Potato chips • Puddings and desserts • Baking
Pharmaceutics	• Roller Bandage • Adhesive • Antibiotics
Cosmetics	• Powders • Creams
Glues	• Glues
Plastics	• Garbage bags
Detergents	• Rinse the laundry • Firmness of the tissues
Paper	• Firmness • Facilitates folding • Disposable utensils
Construction	• Concrete

Source: Orozco et al., 2012
Note: several of these applications result from an internet research while other form the mentioned source.

In Europe, starch products are mainly used as raw material for Food applications (60%) and Feed, Pharmaceuticals and Paper industrial applications (40%), as shown by *Association des Amidonniers et Féculiers* (AFF) [79] in figure 3.13.

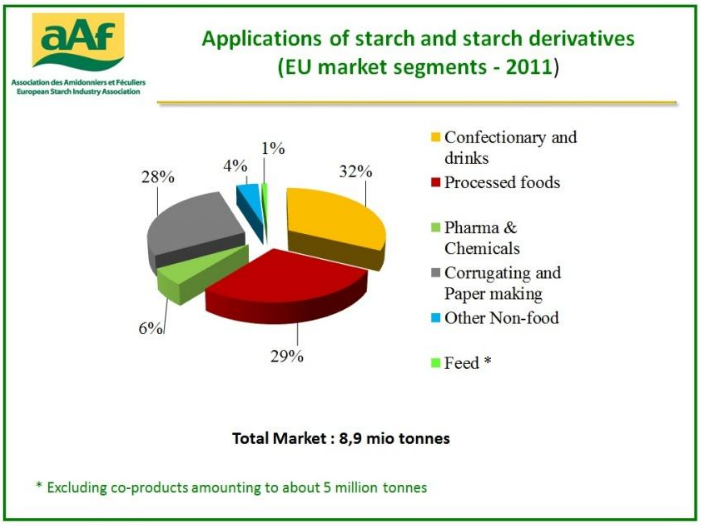

Figure 3.0.13 - Industrial applications of starch and Starch derivatives in European market segments, 2011

3.2.2.2 Potato Starch Market Applications

In 2008, 66 million tons of starch was produced in the world. The major top five producers are USA (50%), China (20%), Europe (17%), Thailand (4,5%) and Brazil (3.5%) [40].

USA is the main producer of starch, about 90% from maize. Americans consume 40% of the maize starch to produce ethanol. USA consumption is also triggered by sugars derived from starch (glicose, maltose, maltodextrin, etc.) because sugar beet and cane sugar are less market competitive sweeteners comparing to the European market [77].

The second biggest producer is China. This producer has been slowly entering the starch market in the last 5 years. China surpassed Europe and also currently selling to it [40].

In Europe, starch production is characterized by more diverse starch plant sources. It is dominated by wheat and potato starch, since other crops cannot sustain the cold weather. Europe intends to get more quote share in this market and offers subsidies to local production and exportation that contributes to the research of renewable fuels [40].

In Portugal there are no potato starch producers. This information was provided by Drª. Susana Silva from the Distributor Company Brenntag. There is however a maize starch producer Industry (COPAM). Therefore, such constitutes a very interesting market opportunity for potato starch production and market entry in Portugal.

Potato starch is decreasing in Europe and around the world. Unlike maize and wheat, potato starches that have valued recoverable residues (gluten and bran for example), potato starch production residues (and cassava) do not have added value. A ton of maize can generate the same volume in commercial products, thus reducing the impact of raw material in the main product price. In another hand, there is an excess of water in potato harvest and potato processing that increases transportation and processing costs [35].

3.2.2.3 Potential Production

This subchapter considers the Portuguese and Campotec company potential starch productions.

To forecast the potential Portuguese starch production it was assumed that all potatoes cultivated in Portugal are destined to be processed for starch production, disregarding the part allocated to Human consume as well as for other Industries. According to Portuguese Agricultural Statistics report by INE [80], Portugal produced 383 and 389 thousand tons of potatoes in 2010 and 2011, respectively (table 3.11). Israilides and co-workers [35] mentioned that losses caused by potato peeling range from 15 to 40% in potato processing plants. With this in mind, it was assumed that 40% of the total Portuguese potatoes cultivated comprise waste peels. In another hand, it was assumed that potato waste peels contain around 1.8% of starch. This value was chose given the proportion between a potato that weights 100g to the 18g of starch it contains [36].

Table 3.9 - Potential Potato Starch Production in Portugal

Year	Potatoes produced (ton)	Potato wastes (ton)	Potential starch production (ton)	Potential potato starch market (M€/ton)
2010	383,835	153,534	**27,636**	**10.88**
2011	389,800	155,920	**28,065**	**10.94**

Source: INE 2011

Notes: The following assumptions were made: i) Potato wastes represent 40% of the total potatoes produced, ii) potato wastes contain 18% of starch and iii) the market PVP of potato starch is 0.39€/kg

According to table 3.11, the potential Portuguese starch production is estimated in 28 thousand tons in 2011 and in the correspondent 10 M€. Internet research allowed to perceive that a Kg of potato starch costs about 0.39€. It is a low price value and the reason why the great quantity of starch is diluted to a relative small market value.

It is important to refer that the encountered potential starch production is not in fact a potential value. This is not only because of the arguments presented in the forecast assumptions, but as well as because it does not consider the starch extraction efficiency provided by BioADD technology. It was not found any literature background proving that is it possible to obtain starch from peels wastes with BioADD technology. It was however found that SW technology degrades starch into glucose, oligomers having various degrees of polymerization, maltose, fructose, 5-hydroxymethylfurfural and furfural [39,81].

Despite the fact that literature cannot provide information regarding the starch extraction efficiency of BioADD technology, a further study is conducted in order to analyse the potential starch production with Campotec potato wastes information.

Dr. Délio Raimundo from Campotec provided important information to proceed with the following potential starch production analysis. Campotec processes about 16 to 20 tonnes of potatoes per day and 30/40% of them are wastes. Therefore, Campotec processes about 5120 to 6400 potatoes per year (320 days). As the company does not have information regarding the quantity of starch present in Campotec' wastes, it was assumed that it constitutes 18% for the same reasons assumed in the above Portuguese potential starch production. Below is presented the potential starch production.

Table 3.10 – Campotec potential starch production

Scenarios	Processed potatoes (tons)	Potato wastes (tons)	Potential starch production (tons)	Potential starch production market (k €/ton)
Scenario 1	5,120	1,792	**333**	**130,000**
Scenario 2	6,400	2,240	**403**	**160,000**

Source: Dr. Délio Raimundo, Campotec company

Notes: **Scenario 1** means that 16 tons of potatoes processed per day; **Scenario 2** means that 20 tons of potatoes processes per day;

The following assumptions were made: i) 35% of processed potatoes are potato wastes ii) potato wastes contain 18% of starch and iii) the market PVP of potato starch is 0.39€/kg

Campotec has the capacity to produce starch in the range of 333 to 403 tonnes per year, given potential potato processing fluctuations. It represents 130 to 160 thousand euros of profit.

3.2.2.4 Potential Market

Considering that Portugal does not have a potato starch producer, all potato starch used in this country must be therefore imported. Through Eurostat database, it was possible to understand that in fact Portugal imports potato starch but also resells part of it. Potato starch import/exportation information in 2011 and 2012 is presented in table 3.13 below.

Table 3.11 - Portuguese international potato starch commerce based in Eurostat database in years 2011 and 2012

	Importation (tons)		Exportation (tons)	
Country	**2011**	**2012**	**2011**	**2012**
Belgium & Luzembourg	0	435	-	-
France	7081	2,234	-	-
China	122	49	-	-
Germany	1964	2,209	-	3
Denmarc	1557	881	-	-
Spain	8387	13,570	849	1,431
Angola	-	-	772	752
Canada	-	-	1	-
Cape Verde	-	-	101	29
UK	-	-	24	4
Guinea Bissau	-	-	6	5
Total Potato Starch (tons)	**19,111**	**19,378**	**1,753**	**2,224**
Total Potato Starch market (M€/kg)	**7.45**	**7.55**	**0.68**	**0.88**

Source: Eurostat

Notes: Total starch market in value was esteemed considering the potato starch PVP of 0.39€/kg multiplied by the total market in tons

Portugal imports potato starch mainly from Spain, France and Germany. Spain is by far the preferred import partner country since this commerce exceeds by almost six times France and Germany, with 13 thousand tons and 2.2 thousand tons in 2012, respectively. Geographical proximity and number of potato starch Industries in those countries may explain this difference.

Interestingly, Portugal does not consume all imported potato starch, but sells it mainly to Spain and former Portuguese colonies (Angola stands out). This is possibly the re-exportation phenomena.

Through equation 3.1 it is possible to esteem the Portuguese potato starch apparent consumption given the absence of potato producers in Portugal (table 3.14). The resultant value represents the Portuguese market of potato starch.

Table 3.12 – Potato Starch Apparent Consumption in Portugal in 2011 and 2012

	Potato Starch Apparent Consumption (tons)	Potato Starch Apparent Consumption market (M€/ton)
2011	17,358	6.80
2012	17,154	6.70

Notes: The apparent consumption market was calculated considering the potato Starch PVP of 0.35€/Kg

In the last two years, Portugal has consumed about 17 thousand tons of potato starch, which represents a 6.7 million euros market. Both these values constitute the Portuguese potato starch market potential. Campotec Company can satisfy about 0.27% of this market if they produced 20 tons of potato residues during 320 days. Considering that all Portuguese potato production was directed to potato starch production, then such production (28 thousand tons) would be able to satisfy the Portuguese potato starch need and even sell 63% to other markets.

3.2.3 Market Decision

After analysing the pectin and potato starch markets, it is now important to select one and proceed to its business plan analysis. Several criteria were taken into consideration to compare both markets. In short, they are: price, potential production and market, technology proof of concept and previous production in Portugal. Table 3.15 summarizes the selection criteria.

Table 3.13 – Selection of BioADD technology market application

Selection Criteria	Pectin	Potato Starch
Price (€/kg)	10	0.39

Potential Portuguese production (ton/year)	11,063	28,065
Potential Portuguese production market (M €/year)	110.63	10.95
Potential Portuguese market (ton/year)	1,127	17,154
Potential Portuguese market (M€/year)	11.27	6.70
Potential Lara production (tons)	1,800	-
Potential Lara production market (M€/ton)	18	-
Potential Campotec production (tons)	-	403
Potential Lara production market (k €/ton)	-	160,000
Technology Proof of Concept	Yes	No
Presence of a manufacturer in Portugal	No	No

Notes: Pectin market potential values result from the analysed in chapter 3.3.1 while the other values result from previous subchapter analysis. When applied, values concern the year of 2012.

Pectin and potato starch have some differences between each other based on the selection criteria of table 3.15. The amount of available valuable wastes to be transformed into both products is higher in potato starch than pectin. This translates into different Portuguese potential productions (28 065 tons and 11 063 tons, respectively). However, despite the fact that the Portuguese potato starch potential production is almost three times higher than that of pectin, both markets are similar in terms of magnitude while the balance swings to the pectin side (6.70 versus 11.27M€ in 2012, respectively). This contradiction is due to each market PVP price. Pectin is the most added value product in the sense that it retails for a higher price (10 €/kg) when compared to potato starch (0.39 €/kg). Moreover, the mentioned values do not consider the absence of potato starch subcritical water extraction proof of concept. Without understanding the technology yield, the doubt of the number closer to the real production potential remains. Nevertheless, this potential would be lower than the actual 28 065 tons of potato starch per year.

Each one of these market presents an opportunity advantage. At the moment there are not Portuguese producers, which imply a free space that BioADD can fill in. Nevertheless, there are competitors in the market that must be addressed.

Regarding the potential production of potato starch and pectin from Campotec and Lara residues, respectively, the scenario is a bit different from the Portuguese one. Lara detains more waste quantities than Campotec and the potential production market is considerable higher for Lara than Campotec (18 *versus* 0.16 M€). Lara sells their residues to animal feed for 20€/ton; this means that the company profits 160 000€ per year. With BioADD Technology, Lara could potentially profit 100 times more. Regarding Campotec, this company pays 0.03€ per kg of residue for the space occupied by their potato wastes in landfills. Therefore, Campotec spends

67 200€ to place their 2240 tons of potato wastes in landfills. With BioADD technology, Campotec would profit above two times this value (160 000€).

In summary, Lara Company and citrus fruit residues comprehend the most favourable market application for SW technology. This decision arises from the reasons discussed above and the fact that pectin constitutes the most added value product and that exists a technology proof of concept in literature.

3.3 Market Outlook

3.3.1 Potential market Dimension

Portugal

It is possible to determine a given country market dimension through analysis of its production, importation and exportation information. To infer the total quantity of a good in a country at a given time period, the Apparent Consumption formula can be used (Equation 1), where it is considered the production, importation and exportation values. This formula allows to esteem the consumption of pectin in Portugal and hence the Potential Market.

$$\textit{Apparent Consumption} = (\textit{Production} + \textit{Importation}) - \textit{Exportation}$$
(Equation 1)

Regarding the Portuguese pectin market, such information is resumed solely to importation and is represented in table 3.16. This table considers the importation of pectin in the last three years.

Table 3.16 - Portuguese international dry pectin importation commerce in years 2010, 2011 and 2012

	2010	2011	2012
	Dry Pectinn (Kg/year)	**Dry Pectin (Kg/year)**	**Dry Pectin (ton/year)**
Switzerland	32	0	0
Check Republic	220	226	368
Germany	128	124	168
Denmark	0	0	6
Algeria	0	1	5
Spain	537	627	529
France	49	11	30
UK	29	11	10
Ireland	0	10	9
India	0	1	2
Total Pectin Quantity (ton)	**995**	**1011**	**1127**

Total Pectin Value (M€)	**9,95**	**10,11**	**11,27**

Source: Eurostat

Notes: Total pectin market in value was esteemed considering the pectin PVP of 10€/kg multiplied by the total market in tons.

Spain, Check Republic and Germany are the top three countries that import pectin to Portugal with 529 tons, 368 tons and 168 tons, in 2012 respectively. Over the years the top importers proportion is maintained suggesting a solid Portuguese pectin market need.

Considering that Portugal does not export or produce pectin, the apparent consumption formula equals the total pectin imported per year and its respective market value. Based on table 3.16, the Portuguese market value in 2012 was **1127 tons**, representing **11 million euros**.

Existing information about pectin market growth is positioned between 3 - 6 % per year. However, there is no confirmation of a specific value. Pectin is a hydrocolloid used as a food additive therefore it is acceptable to consider the Hydrocolloids market growth in order to esteem the European potential pectin market. According to the Summary of IHS Chemical Hydrocolloids report [82], this market is expected to grow 4-6% per year through 2018. In accordance with both data, a 4% per year growth factor was chosen. Figure 3.14 and 3.15 presents the Portuguese potential pectin market forecast until 2018 considering a growth of 4% per year, equally in value and quantity.

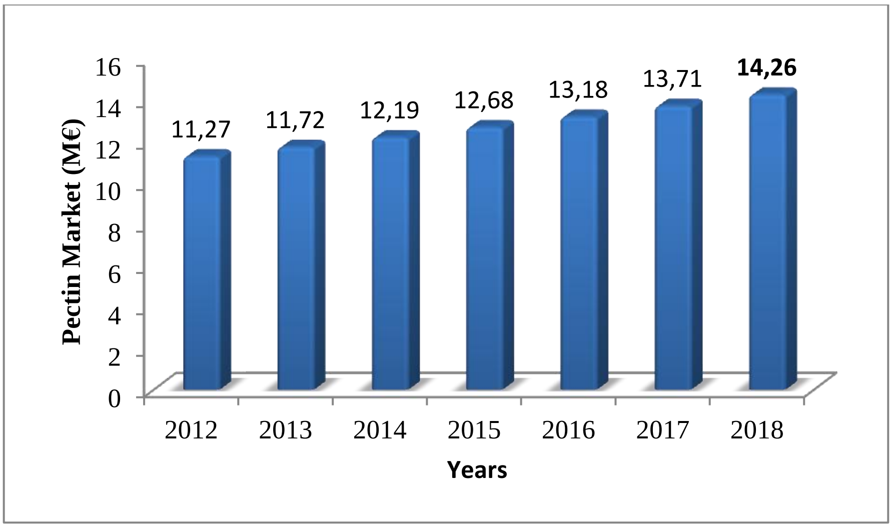

Figure 3.14 - Portuguese potential market size (M€) forecast with 4% growth per year

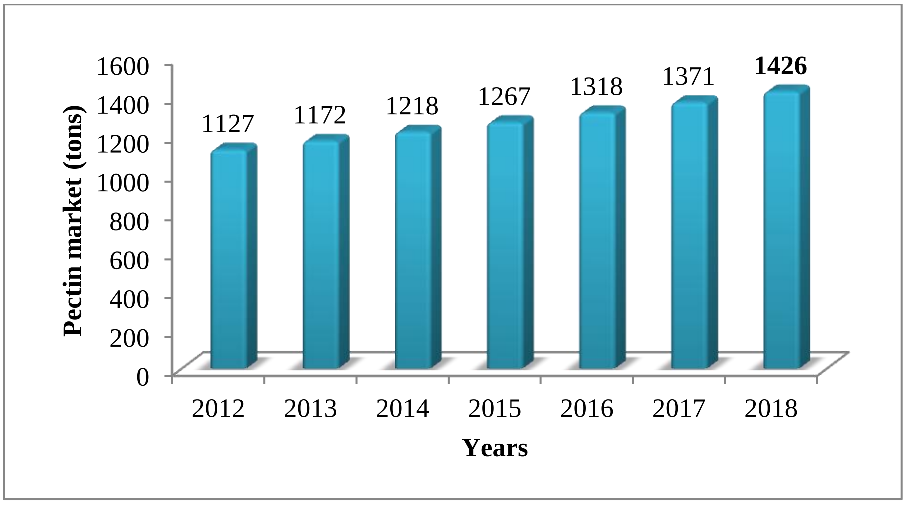

Figure 3.15 - Portuguese potential market size (tons) forecast with 4% growth per year

"*The ingredient is being adopted in more and more foods and beverages*" said Susanne Sõrgel, marketing director of the product line at CP Kelco. Pectin usage in new food applications and population growth justify the pectin 4% forecast value. Thus it is reasonable to consider the Portuguese market forecast values presented in the above table of 14.34 million euros by 2018.

Given the produced pectin characteristics elucidated in table 3.5 (section 3.2) the company will focus on three submarkets: 1) Jams, jellies and marmalades 2) Soft drinks and 3) Yogurt and fermented milk drinks. It is important to esteem the pectin need in each one of these food sectors. The starting point for this forecast is Portuguese sales and production values from 2011, provided by INE [83] (table 3.17).

Table 3.17 - Production and sales of each target food market in 2011

Food Sector	Production	Sales (M€)
Jams, jellies and marmalades	-	8.27
Soft Drinks (Ml)	609.38	351.37
Yoghurt and fermented milk drinks (kg)	110.65	192.17

Source: INE 2011

1) Consume of jams, jellies and marmalades in Portugal was 8.27 M€ in 2011. Estimating that a bottle of jam contains 350g and costs 1.5€, than 1931 tons of pectin was consumed by the Portuguese population in the same year. However, not all producers use pectin in jams, hence it was assumed that 60% of jams, jellies and marmalades contain pectin. This represents 7724 kg. To esteem the pectin need in this food sector in Portugal, the quantity of pectin required in jams was also considered and consists in 0.4% (table 3.18);

2) Regarding the soft drinks Portuguese market, 609 million liters were consumed in 2011. Soft drinks generally contain 0.3% of pectin in its formulation. It was assumed that the ingredient is present in 40% of all soft drinks in order to esteem the pectin soft drinks market need (table 3.18);

3) In 2011, Portuguese population consumed 192 M€ of Yoghurt and fermented milk drinks, resultant from 110 kg production. The quantity of pectin required to perform its function in this food sector is 0.075%. To reach the market need it was assumed that 40% of producers use pectin in yoghurts and fermented milk drinks.

Table 3.18 - Estimative of the pectin market in the following food sectors: Jams, Jellies and marmalades, Soft drinks and Yoghurt and fermented milk drinks in Portugal (2011)

Food Sector	Pectin Food Sector Value (M€)	Pectin Quantity in Food Sector (tons)
Jams, jellies and marmalades	0.05	4.63
Soft Drinks	7.31	731.27
Yoghurt and fermented milk drinks	0.25	24.90
Total	**7.61**	**760.80**

Notes: The following assumptions were assumed in each food sector:

Jams Jellies and marmalades:

- Average price per jam is 350g
- Quantity of pectin in jam is 0.4% [84]
- Pectin is used in 60% of the market
- Pectin price is 10€/Kg

Soft Drinks:

- Quantity of pectin in soft drinks is 0.3% [57]
- Pectin is used in 40% of the Portuguese market
- Pectin price is 10€/Kg

Yoghurt and fermented milk drinks

- Quantity of pectin in yoghurts and fermented milk drinks is 0.075%. This information was provided by the company Goshua
- Pectin is used in 30% of the market
- Pectin price is 10€/Kg

Soft drinks is the food market that uses more quantity of pectin in Portugal (71 tons), followed by Yoghurt and fermented milk drinks (24 tons) and Jams, jellies and marmalades (5 tons). This represents 0.6%, 96% and 3.2%, respectively of the total pectin need constituted by the three markets.

Regarding the total pectin need in Portugal (1127 tons in 2012), all three target markets represent 68% of it. The 32% left is distributed between other Portuguese food applications that use not only HM Pectin, but LM and Amidated as well. Following the same argument, Jams, Jellies and marmalades food sector represents 0.4% of the total Portuguese pectin market; Soft drinks food sector represents 65% of it and Yogurts and fermented milk drinks 2.2%.

Europe

Information to determine the European or International potential pectin market is virtually nonexistent. Pectin producers do not share their sensitive information regarding their production values between other competitors, as well as with European statistical databases. This was confirmed by Dr. Hans-Ulrich Endress (Secretary General of IPPA): "*The questions you asked cannot be answered neither by IPPA nor by an individual pectin producer as the figures and trends you ask for are not collected because of regulations of the competition law, and official statistics are not available*".

The company strategy to overcome the obstacle was to consider the resemblance between the European life expectancy indicators for males and females (table 3.19). Based on them, it is possible to compare the European countries to Portugal and esteem their potential market dimension (table 3.20) based on the population proportion. For example, in Spain lives 50 million people while in Portugal live 10 million; therefore, the proportional factor is 5x. Only the six major populated countries were considered in order to make reasonable forecasts.

Table 3.19 - Life Expectancy at birth for males and females in 2012

	Males	Females
Portugal	76.47	82.60
Spain	78.67	84.90
UK	78.20	82.30
France	78.03	85.03
Italy	79.25	84.55
Germany	77.80	82.83

Source: *Eurostat*

Table 3.20 - European Potential Pectin Market Dimension forecast

Country	Population (M)	Pectin Market Size (M€)	Pectin Market Size (tons)
Portugal	10	11,27	1127
Spain	50	56,35	5635
United Kingdom	60	67,62	6762
France	70	78,89	7889
Italy	60	67,62	6762
Germany	80	90,16	9016
Total Europe	**330**	**371,91**	**37191**

Source: *Eurostat*
Note: Population values are approximated to the nearest entire number.

The European potential pectin market size is 37191 tons, corresponding to nearly 372 M€. Recalling the Portuguese market previously estimated in 11.27 M€ (1127 tons), Portugal detains 3% of the European market. This is the same as reporting that the European pectin market is 33 times bigger than Portugal's one.

Considering the Hydrocolloids 4% market growth estimated until 2018, it is also possible to forecast the potential European pectin market both in value and quantity (figure 3.16 and 3.17). In 2018, the European total pectin market need will be 47 000 tons, equivalent to 471 M€.

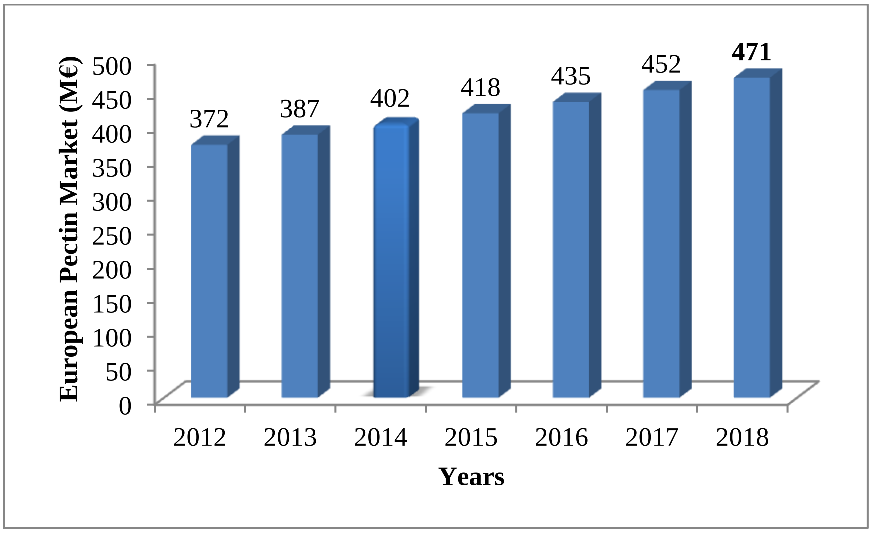

Figure 3.16 - European potential pectin market size (M€) forecast with 4% growth per year

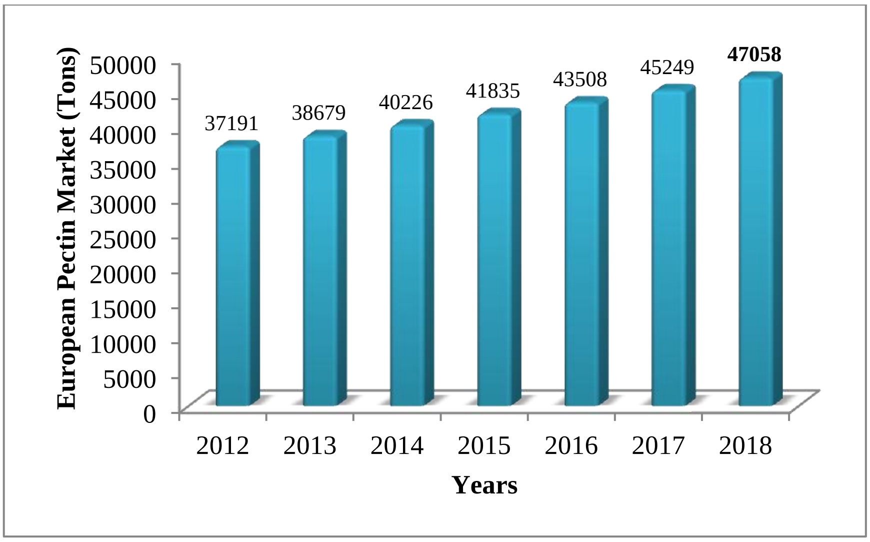

Figure 3.17 - European potential pectin market size (tones) forecast with 4% growth per year

The approach used to esteem the European total pectin market need can also be applied for the three food sectors. The proportion factor now considered is 33 times because the European market is 33 times bigger than the Portuguese one. Each food sector forecast is presented in table 3.21.

Table 3.21 – Portuguese and European pectin market forecast for Jams, jellies and marmalades, Soft drinks and Yoghurt and fermented milk drink food sectors

Food Sector	Portugal		Europe	
	M €	**Tons**	**M €**	**Tons**
Jams, jellies and marmalades	0.05	4.63	1.53	152.95
Soft Drinks	7.31	731.27	241.32	24,131.77
Yoghurt and fermented milk drinks	0.25	24.90	8.22	821.61
Total	**7.61**	**760.80**	**251.06**	**25,106.33**

The sum of BioADD' targeted markets is defined in 25 000 tons, nearly 14 times its potential production. The food European pectin market is higher in comparison with Portugal and constitutes a larger interesting market that can absorb BioADD PectiCitrus production.

The initial Portuguese proportion was maintained, that is, Soft Drinks market represents 96% and 68% of total pectin need in the tree markets and total European pectin need, respectively. Likewise, Jams, jellies and marmalades represent 0.6% and 0.5%; and Yoghurts and fermented milk drinks represent 3.2% and 2.2% of the mentioned markets.

Each of the food markets has a specific market growth determined by current trends, food industry and final consumer purchase options:

→ Soft drinks have a market share of 46.8% within the non-alcoholic industry. This industry was valued in $47.2 billion (35.4 billion €) in the United States in 2010. The industry's annual growth was **1.8%** from 2005 to 2010, and it is expected to maintain this growth rate between 2010 and 2015 [85]; In Europe, soft drinks detain 45% market share of drinks, resulting in 32.6 billion euros market [86];

→ EU consumption of jams, jellies, pastes and purees in 2008 were quantified in 2.0 billion € and 1.2 million tonnes. The largest markets are Germany, United Kingdom, Italy, France and Spain. The main producers are Germany, Italy and UK. In 2008, production of jams, jellies, pastes and purees was €2.3 billion and 1.3 million tonnes [87];

→ The milk market was estimated in approximately 20 bn € in 2006 [88]. The EU's main producers are Germany, France, the United Kingdom, the Netherlands, Italy and Poland which together account for more than 70% of the EU production. In 2011 the market was estimated in 152 million tones [89].

3.3.2 <u>Segmentation & Targeting</u>

In market perspective, BioADD intends to be the link between fruit juice processing companies (Partners) and pectin buying companies (Clients). The company will carry out the flux of acquiring orange peels and transform them into pectin, selling it to another company. The later will incorporate the pectin into different final products. These will then be sold to final consumers. In light of these arguments, the BioAdd market is B2B (Business to Business) and not B2C (Business to Consumer) because strategies and revenues are oriented towards companies.

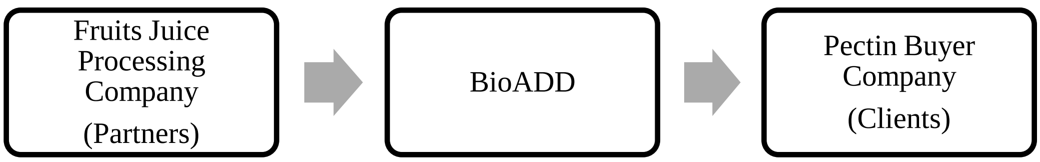

Figure 3.18 - BioADD positioning between partners and clients

It is therefore important to develop segmentation criteria for each type of company in order to taper the market entry strategy. Below is discussed and presented the segmentation criteria and targeting for each client.

<u>Segmentation Criteria for Fruit Processing Companies</u>

The selected segmentation criteria for this partner are the following and are further discussed in targeting:

1. High cost with treatment, storage and transportation of the residue;
2. High volume of residues produced;
3. Amount of pectin present and able to be extracted from residues;
4. Geographical localization.

→ **Targeting**

Costs of fruit processing companies are generated by the treatment of fruit wastes, storage and transportation. A solution for these enterprises is to either pay for the residues to be deposited in a landfill or sell them to interested companies like animal feed producers. However the return often is not enough to cover transportation and storage costs or there is not an interested buyer available, according to several contacted Portuguese Fruit processing Companies[1]. Other companies obtain profit from their fruit residues sales, either because they have market valuable residues or detain large amounts of it. BioADD is interested in negotiating and targeting companies that fall in the first context because they are the ones where there is a need and a problem to be solved. The focus is to partner with Fruit Processing Company's by presenting a solution to their fruit waste problem while developing a profitable business association. The Fruit Processing Company will choose to work with BioADD or not.

It is also very important that the fruit processing company produces a high volume of fruit residues. If the production volume is low, then there will be struggles to suffice the pectin market demand. This criterion is associated with the amount of pectin in residues; high volume of wastes does not imply that pectin will be easy accessible in the structural heteropolysaccharide fruit residue. BioADD is determined to target companies who obtain large volumes of waste and contain around 0.15 – 0.35% of pectin in peels, to profitably suffice the market demand.

<u>Segmentation Criteria for Pectin Company Buyers</u>

The selected segmentation criteria for this client are presented below and discussed afterwards in targeting:

1. Companies who are inserted in the following food sectors: a) Jams, jellies and marmalades, b) Soft drinks and c) Yoghurt and fermented milk drinks;

[1] Lara, Inofruta, Campotec, 80G and Biofun companies

2. High volume necessity of pectin
3. Annual cost with Pectin

→ **Targeting**

PectiCitrus produced by BioADD is High Methylated pectin. It can only be used in specific food applications as an ingredient. Hence, the most important BioADD client target is a company who purchases and needs pectin in these food sectors: a) Jams, jellies and marmalades, b) Soft drinks and c) Yoghurt and fermented milk drinks.

The second segmentation criterion is related to pectin demand that BioADD can satisfy. The bigger the need in terms of pectin the most the company will profit. This criterion is intertwined with the third one. Clients buy pectin and consequently spend low or high values with it depending upon the pectin seller. By targeting companies who buy great quantities of pectin, BioADD can use the competitive price strategy to gain these clients while diminishing their overall cost. BioADD will then target companies with high pectin annual cost combined with high quantity necessity of pectin.

In a first approach, BioADD will establish partnerships with Portuguese companies given the fact that Portugal is a traditional producer of citrus fruits. Also, the industrial residues from orange processing companies do not seem to be used for pectin manufacture by competitors and can be valued into the high added value product PectiCitrus.

3.3.3 Positioning

Positioning relates to the way a product occupies a clear, distinctive, and desirable place relative to competing products in the minds of target consumers [90].

The start up company BioADD is focused on valorizing waste residues that have a high market value potential through the utilization of sustainable technologies. The core business is to produce pectin. The company is positioned as a food additive manufacturer in the food chain.

Food wastes constitute a large under-exploited residue from which a variety of valuable compounds can be derived. With the aim of managing waste in the most sustainable way, the company established a partnership with the fruit processing company Lara.

PectiCitrus will enter the market as a green and natural waste valuable product obtained from citrus peels. The final product owns the same exact characteristics as other branded pectins available in the marketplace. Characteristics like the clear beige/white color, mouthful flavour, and gelling and thickening properties are the same. The source of raw material is identical, meaning that pectin derives from the structural heteropolysaccharide contained in the primary cell of terrestrial plants and albedo of oranges.

The BioADD technology used does not alter the composition of the pectin from the universally known one. The key point of using this green sustainable technology, in comparison with technologies currently employed in the market, is the utilization of water instead of organic or other solvents to extract pectin. Water is a clean, pure and non-pollutant solvent. Under certain temperature and pressure conditions, water is able to extract compounds otherwise extracted with pollutant substances. Nowadays, pollution from chemical processes is visualized as a global concern and against green environmental practices. Therefore, clean technologies are seen as the future sustainable approach to a healthy world. Concerning the product food application, the usage of water and no more additives is very important to ensure healthy and safe PectiCitrus ingredient.

Pectin applications are versatile. There are several applications in different food industries. Pectin is an ingredient and food additive that can be used for example in Jams/jellies, Dairy Products, Soft Drinks, Ice creams, etc., Food industries. The business focus of BioADD is to sell PectiCitrus to food companies that require this ingredient in their food preparations. These companies belong to Jams, jellies and marmalades, Soft drinks and Yoghurt and fermented milk drinks food sectors.

Food consumers are increasingly aware of food ingredients origin and worried with non Natural sources. Food Producers will be able to satisfy this growing trend and demand by providing a product with sustainable, natural and green characteristics if the company's PectiCitrus is used. The key factor is that Food Producers get to offer health options to their clients by purchasing the same quality pectin as before but for a very competitive price in the market.

3.4 Competitors

The nature of BioADD business is to produce pectin from orange peels. Pectin is a commodity product that is industrially produced by several multinational companies. The company is going to directly compete with companies that produce HM Pectin. At the international level there is only a single company focused on producing pectin (Herbstreith & Fox). The other companies produce pectin as well as several hydrocolloids, some of which compete indirectly with the company's pectin.

Global pectin market was esteemed in 319 M$ (40 M€) [91] in 2010, with an annual growth of 4-6% per year. However, due to regulations of the competition law it is not possible to have an exact number or determine the market share of each company. General pectin market price is 10€ per Kg and this information was provided by Dr. Hans-Ulrich Endress (Secretary General of IPPA). However, some Portuguese pectin consumers[2] state that they purchase pectin for 13€ and 15€ per Kg from outside Portugal.

Direct Competitors

Pectin market is dominated by large international producers, mainly from Europe, followed by USA and China. Besides the biggest producers, there are random smaller players in the worldwide market. In Europe there are seven pectin manufacturers, three major players (Danisco, Naturex and Herbtreith & Fox companies) and five smaller ones. The largest markets are dominated by a small number of multinational players with consolidation a recurring theme over the past decade, driven by increasing competitiveness and a consolidating customer base.

Pectin manufacturers generally produce three types of pectin from apple and orange pomace to satisfy several food applications sectors: HM, LM and Amidated pectin's. Moreover, several companies detain pectin products specified for certain market food applications, thus extending their current lines. To compete with pectin manufacturers, the company will produce HM pectin from waste citrus peels. This way, the company will not face further operational costs and stay focused in acquiring market share of the specific high methylated pectin market. The choice of the food sectors where PectiCitrus will be used drift from the HM Pectin product obtained with BioADD technology discussed in chapter 3.2. Furthermore, through partnership with fruit processing companies, the company is able to value fruit wastes.

Regarding the Industrial pectin manufacture procedure, it seems that none of the competitors uses the same technology as BioADD does. Also, there are several differences between the traditional process and BioADD technology. It is then relevant to describe the traditional manufacture process and compare it to BioADD.

At the Industry level, pectin is traditionally extracted from citrus and apple dry peels using aggressive chemical substances. Each Producer has developed their suitable extraction conditions, but overall, all follow the process steps presented in the scheme below and described in detail in table 3.22.

[2] Companies wish to remain anonymous

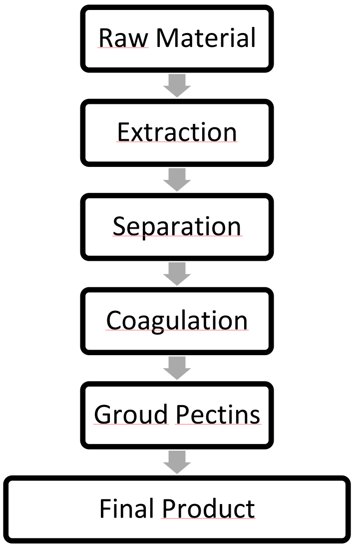

Figure 3.19 - Traditional pectin extraction method main steps

Table 3.22 - Industry Pectin Extraction steps and description

Process steps	Description
Raw Material	The source of raw material is determinant to the type of pectin obtained and its commercial final applications. Citrus an apple peel are the most commercially used raw materials, resulting in pectin with different characteristics. It is also important to select the fruit peel origin and availability since different sorts of citrus, for ex, have different methyl and galacturonic acid contents [32].
Extraction	Industrially, pectin is extracted by treating the raw material with hot dilute mineral acid at pH 1.5 - 3 and 60 - 100ºC [55]. The extraction time is decided upon the desired pectin and its suitable application per each manufacturer [14,15]
Separation	Upon extraction, pectin is in the form of a hot viscous extract. Viscosity increases with pectin concentration and molecular weight. The extract is clarified through centrifugation, filtration and pressing in order to concentrate pectin and loose original solid materials. These cycles are repeated as many times as the manufacturer judges necessary to obtain purest pectin [11, 15, 16]
Coagulation & Ground Pectins	After separation, apple pectin is treated with carbon in order to remove the color and with the enzyme *α-amilase* in order to degrade the starch. The clarified extract is then concentrated in vacuum. To obtain powdered pectin, the liquid concentrated extract either from citrus or apple is mixed with an alcohol (usually isopropanol). It is obtained a stringy gelatinous mass that is then pressed and washed to remove the mother liquor, dried and ground [15,16]. The extracted type of pectin in this stage is HM Pectin. To further obtain LM Pectin and Amidated Pectin the purification process is lengthened with de-esterification and amidation procedures [52]
Final Products	In this step the pectin obtained is packed or blended to produce several types of pectins.

Source: May, 1990

Upon analyzing the Industrial pectin extraction, remains an important question that how BioADD technology compares to it and what are its advantages over the traditional method.

Technically, BioADD technology will replace the usage of hot mineral acids in the traditional extraction method. Further purification steps will still be required and be similar to the traditional method as detailed in chapter 2. According to literature [21,33], HM pectin yield from orange peels is higher than 75% in the traditional methods and is a quicker reaction than the traditional one. The last is a presupposition because subcritical water is a fast reactant, but BioADD technology reaction will be further scaled-up before commercialization. It has also been reported by the authors extraction of orange pectin above 75% methylation degree while the traditional extraction procedure goes up to 75% [32]. Regarding the solvents used, BioADD technology only requires water, a safe and harmless solvent. The traditional method requires solvents that are hazardous to the environment, like Isopropanol, methanol, chloride acid, phosphoric acid, nitric acid and sulfuric acid [58]. The following table 3.23 summarizes the comparison between traditional and BioADD technology. Industrial traditional manufacture of pectin remotes the 20th decade of last century and BioADD technology is a new technological approach to the HM Pectin product. It is proven that pectin is a commodity safe product; however, BioADD faces a challenge by entering a market dominated by huge knowledgeable players. Table 3.23 below summarizes the comparison between traditional and BioADD technology.

Table 3.23 - Subcritical Water and Industry Extraction technologies comparison

	Subcritical Water	Industry Process
1) HM Pectin Extraction Yield	Above 75%	Less than 75%
2) Extraction time	Fast	Low
3) Degree of Esterification	Above 75% for citrus pectin	Up to 75% of citus pectin; At least 80% of apple pectin
4) Solvent Usage	Water	Utilization of organic solvents (isopropanol, methanol)
5) Cost Savings	Savings in using the closed cycle of water flux	Higher costs with organic solvents and their disposal
6) Industry proof of concept and knowledge	Limited and little knowledge	Vast and very knowledgeable

Source: May, 2009

Notes:

1) All types of fruits have pectin in their constitution in diverse quantities. Subcritical water allows extraction of higher methylated HM pectin than the industrial method [21,33].

2) Subcritical water is a fast method requiring less amount of time than the traditional method to allow water interaction with the raw material.

3) According to the literature, Ueno and collaborators [21] as well as Hoshino and collaborators [33] extracted pectin from *Citrus junos* peel with 80% yield using subcritical water. Colin May states that traditional processes cannot extract citrus pectin with more than 75% and can extract apple pectin with at least 80% esterification degree [32]. This may be due to the presence of pectin esterase in citrus fruit. Extraction of apple pectin with subcritical water technology has not yet been reported.

4) Pectin Production traditionally requires utilization of environmentally hazardous strong acids like HCL, HNO_3, H_3PO^4 and H_2SO^4 [58]. Organic solvents usage does not favor the environment and as volatile and toxic elements must be handled carefully needing proper control. Subcritical Water technology uses a single solvent

supply that is an environmentally friendly and cleaner one, water.

5) Water is continuously used and recycled during Subcritical Water Extraction avoiding extra expenses and fewer costs. Organic solvents, in another hand, need extra costs because 1) they are more expensive, 2) need proper storage with safety measures and 3) need recovery steps and disposal methods to not harm the environment.

6) The pectin business started in the 20th decade of last century. There is enough proof of concepts that pectin is safely produced and sellable in the scientific and market communities. Regarding Subcritical Water technology there are only two papers in the scientific community that proof it is possible to extract pectin form orange peels with this technology. No industry (as far as it was able to understand) produces pectin with BioADD technology, therefore the company faces a huge knowledge gap regarding the operations required to obtain pectin with specific conditions.

The company will enter in the European market through European Distributors that also sell in the Iberian Peninsula. The goal is to conquer 3% of the EU market. There is not a pectin manufacturer in Portugal and this pectin market is diffused between Distributors and Online pectin purchases. Through contact with Portuguese Distributors, the company found that major pectin buyers (like Lactogal, Danone and Nestlé for ex.) do not purchase pectin in Portugal and some are not aware of other pectin Distributors in the market. This reveals an immature market that BioADD can nourish.

Indirect Competitors

Pectin indirect competitors are hydrocolloids that perform the same functions in Food Industry. They are food additives that have the same properties as pectin: stabilizer, thickener, binder and texturizer. The mentioned hydrocolloids are naturally occurring, either plant or fruit-based products and are detailed in table 3.24, according to each *Company* target Food Niche.

Table 3.24 - Indirect Pectin Competitors: Hydrocolloids

Food Sector	Hydrocolloids
Fruit Preparations, Jams and marmalades	Alginates, Carrageenan, Guar Gum, Pectin, Xantan Gum
Beverages	Carrageenan, Guar Gum, Gum Arabic, Pectin, Xanthan Gum
Dairy, acidified/fermented drinks, desserts	Pectin

Source: Brenntag Specialties

Notes:

- **Algin (E401)**: or Alginates are a cell wall skeletal component of all brown algae (*Phaeophycea*). The major source of industrial production is the giant *Macrocystis pyrifera*. The polysaccharide is extracted with alkalies and usually precipitated by acids or calcium salts [55]; Alginate offers properties in processed foods and beverages such as gelling, viscosifying, suspending and stabilizing. Alginate gelling may be achieved using calcium under controlled conditions. The process may be performed under cold conditions at neutral or acid pH [92]**.** A kilogram of sodium alginate costs around 47€ in the market**.**
- **Carrageenan (E407)**: are isolated from Chondrus (*Chondrus crispus*), *Euchema*, *Gigartina*, *Gloipeltis* and *Iridiaea*, all red sea weed species. It is obtained by hot water extraction under mild alkaline conditions, followed by drying or isolate precipitation [55]. Carrageenan is a sulfated linear polysaccharide of D-galactose and it has a strong negative charge, thereby allowing it to stabilize gels or act as a thickener. Carrageenan is found in numerous products, ranging from toothpaste to soy milk. It is used to suspend cocoa solids in beverages, for example, and can be used in meats to reduce cooking losses [92]. A kilogram of carrageenan K costs around 66€ in the market.
- **Gum Arabic (E414):** is a tree exudate of several Acacia species and is obtained as a result of tree bark injury. Gum Arabic is a unique molecule and contains 2 to 3% peptides as an integral part of the structure. It is believed that these peptide fractions are responsible for the emulsifying capacity. Gum Arabic is

collected as air-dried droplets with diameters ranging from 2 to 7cm. The annual yield per tree averages 0.9-2.0 kg. The major producer is Sudan, followed by several African countries [55]. Gum Arabic forms very low viscous solutions and concentrations up to 50% can be achieved [53]. The market price of gum arabic is 7€/kg. It is subject to Sudan's annual inflation (expected to be 46.5% in November 2013) and has continuously increased in the last three years [93].

- **Guar Gum (E412)**: is obtained from the seed endosperm of the leguminous plant *Cyamopsis tetragonoloba*. The plant in cultivated for forage in India, Pakistan and the United States [55]. Guar gum is a carbohydrate consisting of mannose and galactose at a 2:1 ratio that can swell in cold water. Guar gum is an efficient water-thickening agent for the food industry and is widely used as a binder and volume enhancer. Its high percentage of soluble dietary fiber (80 to 85%) means that it is often added to bread to increase its soluble dietary fiber content. Guar gum is also commonly used to thicken and stabilize salad dressings and sauces and help improve moisture retention in finished baked goods [92]. Guar gum is uniquely supplied from India and costs near 1€ per kilogram.
- **Xanthan Gum (E415):** is the extracellular polysaccharide from the microorganism *Xanthomonas campestris*. It is produced on a nutritive medium containing glucose, NH_4CL, a mixture of amino acids and minerals. Isopropanol precipitation in the presence of KCL is applied to recover the polysaccharide from the medium [55]. Xanthan gum acts alone to form viscous, pseudo-plastic solutions. In combination with guar gum, a synergistic viscosity development can be noticed [53]. The market price of Xanthan gum averages 40€/kg.

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When purchasing ingredients, Food Producers will opt for either pectin or one of the hydrocolloids that gives the best performance. This is after considering the food chemistry specifications and market applications. Many hydrocolloid share similar properties as well as several hydrocolloids can deliver the required functionality. The numbers of influencing factors that determine the right hydrocolloid choice are numerous and these can also influence each other [53]. pH range, solubility, acid stability and solution clarity are examples of influencing factors in the choice of the correct hydrocolloid. Pectin is one of the cheapest hydrocolloids available and small quantities of it provide products with high and excellent gel strength, thickening and texture properties. Pectin also holds a very good cost-benefit feature because it only takes small quantities of the product to achieve the desired performance.

3.4.1 Performance & Perceptual Map

Performance Map

PectiCitrus will directly compete with HM pectin international manufacturers. The six main worldwide producers of HM pectin are Herbstreight & Fox, Danisco, Cargill, CP Kelco, Naturex and Yantai Andre Pectin. The HM pectins they individually produce are H&F Classic pectin, GRINDSTED® Pectin SF, Unipectine® Pectin, GENU®Pectin, and APectner, respectively. The following map compares the performance of PectiCitrus to competitors according to four attributes: 1) waste residue valorization, 2) versatility, 3) green solvents and 4) price:

Table 3.25 – PectiCitrus Performance Map

	Pecti Citrus	H&F Classic Pectin	GRINDSTED Pectin SF	Unipectine Pectin	GENU Pectin	NATexture	APectner
Business Model	😃	😐	😐	😐	😐	😐	😐
Versatility	😐	😃	😃	😃	😃	😃	😃
Green Solvents	😃	☹️	☹️	☹️	☹️	☹️	☹️
Price	😃	😐	😐	😐	😐	😐	😐

Notes: i) Waste valorization takes into account if the raw material is an Industrial waste;
ii) Versatility considers if the product and competitors have the ability to be used in several different market applications;
iii) The criterion green solvents analysis if the solvents used are green and safe for the environment
iv) The criterion price compares the market value of each product

1) Business Model – PectiCitrus raw material is orange peels resultant from an Industrial waste. It is unknown if the source of raw materials for the competitors products are resultant from industrial wastes; However, in literature [94] it is reported different citrus peels country origins for Cargill, Danisco and Yantai Andre Pectin producers (detailed in the following sub chapter). Therefore, it is quite possible that they come from industrial wastes.
2) Versatility - the six competitive manufacturers detain versatile products. Herbstreight & Fox HM classic pectin can be used in several market applications, as well as all competitors analysed. PectiCitrus will be able to be used in three major market applications and has the potential to be further used in more applications in the future.
3) Green Solvents – PectiCitrus manufacture only requires water as solvent. Water is a safe and clean solvent as well as not harmful to the environment. Assuming that competitors obtain their products through the traditional manufacture process, then they use environmental harmful solvents in their manufacture.
4) Price – PectiCitrus will be sold with the price of 9 €/kg. This price was stipulated in order to compete with HM Pectin manufacturers who sell their pectin at admittedly 10 €/kg. BioADD sale projections and financial plan stands in accordance with this price.

<u>Perceptual Map</u>

A perceptual positioning map is created by marketers with the purpose of presenting consumer perceptions of their brand versus competing products on important buying dimensions [95]. BioADD perceptual mapping is based on two positioning axis: costumer benefit *versus* sustainability. These are the criteria that BioADD beliefs that distinguishes PectiCitrus from its market competitors.

By consumer benefit it is understood the gain that the consumer obtains for purchasing PectiCitrus. Customers benefit with PectiCitrus competitive price *versus* other similar products in the market and BioADD *know-how*. Additionally, BioADD strategy of partnering with fruit processing companies allows BioADD to provide this competitive leverage.

Sustainability encompasses environment, social and economic long-term maintenance and health features [47]. Sustainability covers the heritage of nature that conveys to future generations. From the viewpoint of human intervention, the economy must respect the limits of natural ecosystems and act in accordance with the principles of social equity. In BioADD perceptual map, it encloses i) the green source raw material; ii) waste residue valorization and iii) green and clean solvent usage in the production process.

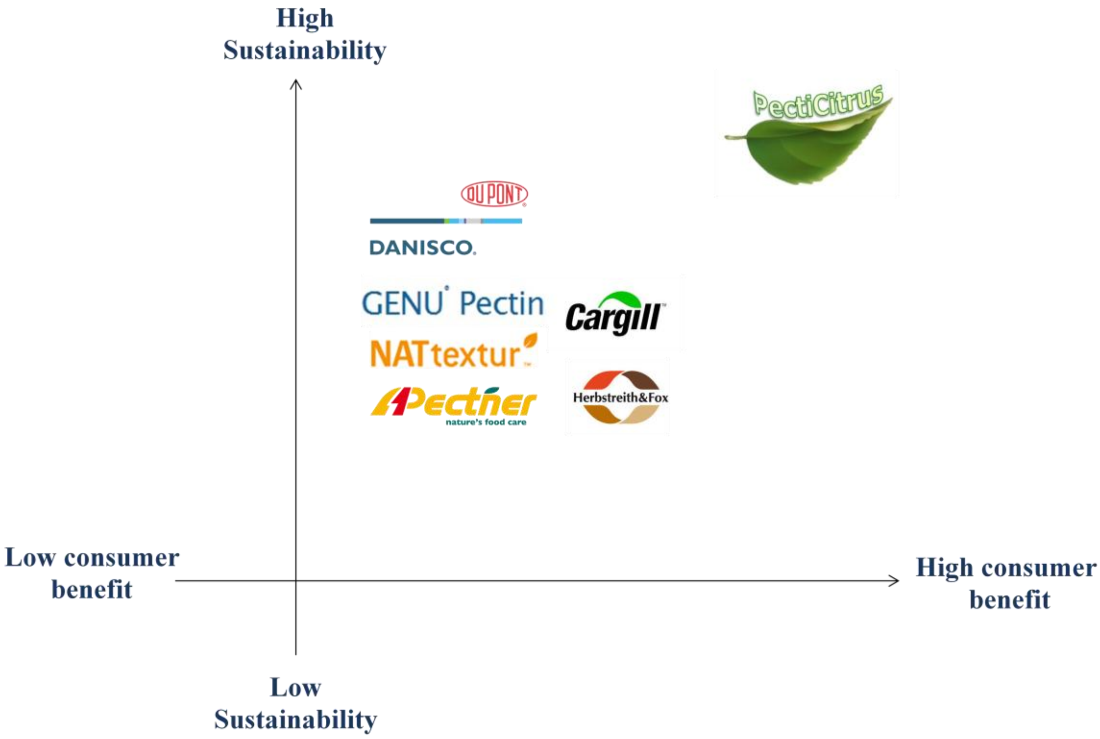


Figure 3.20 – PectiCitrus Perceptual map

Positioning of competitors and PectiCiturs presented in the above PectiCitrus map is located in a single quadrant. It is important to bear in mind that pectin is a commodity product that must follow certain chemical specifications in order to be used in the Industry. The perceptual map evidences that there are not huge differences between different branded products. PectiCitrus is positioned in the top right corner due to the fact that overall it is more sustainable than its competitors. Also, BioADD is able to provide a product with high quality standards for a lower market price.

3.4.2 Existing Companies

As mentioned earlier there is not a company who produces pectin in Portugal. However there are several around the world. Existing companies are presented below in table 3.26.

Table 3.26 - Pectin Worldwide Producers

Company Name	Headquarters	Website
Herbstreith & Fox	Germany	http://www.herbstreith-fox.de/
Danisco	Denmark	http://www.danisco.com/food-beverages/
Cargill	USA	http://www.cargill.com/
CP Kelco	USA	http://www.cpkelco.com/
Naturex	France	http://www.naturex.com/
Yantai Andre Pectin	China	http://www.andrepectin.com/
SilvaTeam	Italy	http://en.silvateam.com/
Lucid Colloids	India	http://www.lucidcolloids.com/
Calleva	UK	http://www.calleva.uk.com/pectin.php
Pektowin Jaslo	Poland	http://www.pektowin.com.pl/
Ceamsa	Spain	http://www.ceamsa.com/

Source: *IPPA*
Notes: Companies are listed in decreasing order of importance. The first four companies are listed in IPPA website while the rest of the companies were identified through a deeper search on the internet. Therefore it is possible that they have a lower market share in the pectin market.

According to Yantai Andre Pectin company report [94], there are six major pectin manufacturers: Cargill Texturizing Solutions, Naturex, Herbstreight & Fox KG, Danisco Ingredients, CP Kelco and Yantai Andre Pectin.

Cargill Texturizing Solutions corporate headquarters is located in USA. The company owns two pectin production sites: Redon in France and Malchin in Germany. Cargill produces apple and citrus pectin from apple pomace and citrus peels, respectively. The raw materials come from France, Northem and Central EU (apple pomace) and US, Brazil, Argentina, Mexico and Mediterranean basin (citrus peels) [94]. Its business is organized under five major segments: Agriculture Services, Food Ingredients and Applications, Origination and Processing, Risk Management and Financial, and Industrial. It is present in 65 countries. The Malchin plant has a capacity of 4 500 tonnes [96].

Naturex is located in France and produces apple and citrus pectin from apple pomace and citrus peels, respectively. Its pectin production takes place in Switzerland. Naturex develops natural, healthy and safe ingredients for the food, beverage, flavour, nutraceutical, pharmaceutical and cosmetic industries. It holds 15 production units across the world.

Herbstreight & Fox KG headquarters is located in Germany and is the only company focused on producing and selling pectin, while the others mentioned sell more commodity products. Herbstreight & Fox produces apple and orange pectin from apple pomace and citrus peels, respectively. The company owns two production plants in Neuenbürg and Werber (installed in 2012), Germany. The first plant capacity production is 2 600 Mtons and the second is 2000 tons.

Danisco Ingredients is DuPont subsidiary specialized in products that help provide enhanced bio protection, an improved nutritional profile, and better taste and texture. Its target market is Food and beverages, dietary supplements and pet food. Danisco also produces pectin from apple pomace and citrus peels. Danisco own three pectin production plants in Mexico, Czech Republic and Brazil. Danisco holds 25% of the pectin market share [94].

CP Kelco is a subsidiary of JM Huber Company and its headquarters are in Denmark. CP Kelco also produces pectin from apple pomace and citrus peels. CP Kelco detains three pectin manufacture plants: Limeira in Brazil, Grossenbrode in Germany and Lille Skensved in Denmark. Danisco raw materials come from South America and Europe [94]. The business scope of this company is Hydrocolloids that are produced around 9 facilities.

Yantai Andre Pectin is the leader of the pectin market in Asia and a subsidiary of Yantai Andre Juice (8259 HK). The company headquarters and production facility is in Yantai, China and its raw material comes from South America [94]. The company enjoys large demand of products from China and high gross margin of approximately 40% through the low operating cost in China.

3.4.3 Market Readiness

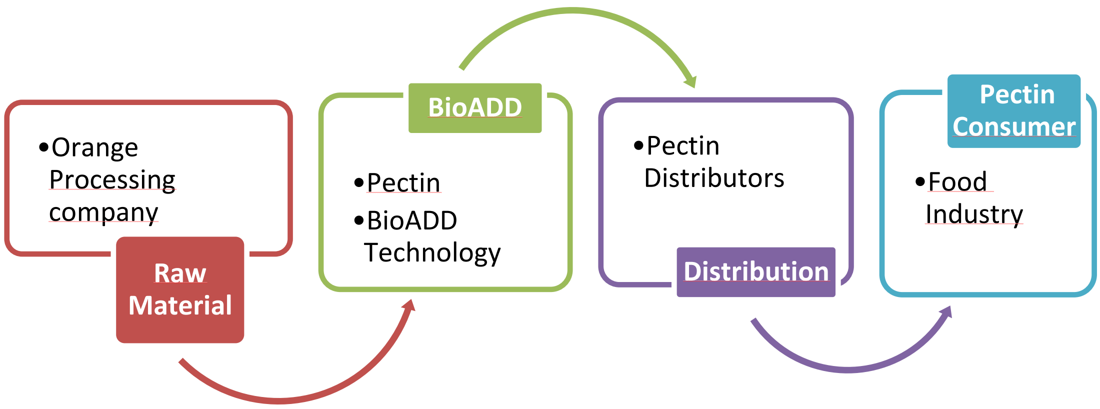
Pectin market is developed and pectin is not a new product. The market is then ready to accommodate the company's commodity product.

The technology used to produce pectin is not a disruptive one either. The original feature of the company is its business plan. The company considers the market readiness to be quite good.

3.5 Supply Chain

3.5.1 Pectin Market Chain

Figure 3.21 – Pectin Market Chain diagram



Raw Material

The raw material to produce pectin is orange peels. These are obtained in orange fruit processing companies.

Product Manufacture

BioADD will produce pectin from orange peel wastes through Subcritical Water Technology.

Distribution

BioADD will sell to the Distributor who will then sell to the Food Industry.

Pectin Consumer

The end of the pectin value chain is the food Industry. Food producers (mainly: yoghurt, milk, jams, ice creams, juices, soft drinks, etc.) use pectin as one of the ingredients. Target consumers in a first approach are the ones operating in Jams, Jellies and marmalades, Soft Drinks and Yoghurt and acidified milk drinks food niches.

Potential raw material Suppliers

In Portugal there are several orange peel fruit suppliers. The suppliers are as well viewed as potential partners. They are listed below in table 3.27.

Table 3.27 - Portuguese raw material suppliers for pectin production

Orange Processing companies
Lara
80G
Inofruta

Source: INE Portugal

Table 3.28 - Portuguese potential production of pectin in 2012

Company	Orange Pectin (ton)
Lara	1680,00
80G	1,05
Inofruta	2,71

Source: Data provided by Eng. Paulo Duque (LARA food engineer), Eng[a]. Daniela Ribeiro (80G Responsible for Production and Quality), Eng. Pedro Oliveira (CEO of Inofruta company)

Considering the table 3.28 above, Lara is the company who dominates the market of orange processing in Portugal and satisfies the segmentation criteria (see section 3.3.2).

The other companies remain potential suppliers, however their waste volume production and consequently productivity is too small to be considered.

3.5.2 Distribution Channels

The distribution channels chapter analysis how BioADD will reach its product customers. There will one forms: indirect distribution.

Indirect distribution – through this option, BioADD will sell its pectin product to an intermediary. It can either be a distributing or wholesaler company. The intermediary is then responsible to sell that product to the final Food Industry.

The distribution companies can be selected according to the geographical areas where they work. BioADD will focus in Portuguese and European markets through selection of Distributors that preferably operate in both markets. In compliance with the company market entry strategy, they are summarized under Portugal (table 3.29) and International (table 3.30) geographical areas.

Table 3.29 - Distributors of Pectin in Portugal

Company	E-mail
F. Lima	flima@flima.pt
Brenntag Portugal	susana.silva@brenntag.pt
Neoquímica	food@neoquimica.pt
Sameca	invgest@sameca.pt

Source: INE

Table 3.30 - International Distributors of Pectin

Company	E-mail
Aromat Hellas	info@aromathellas.gr
Brenntag Group	-
CHEMaster International Inc	-
Frutica	info@frutica.com.ua
Harsh and Company	-
Parchem	info@parchem.com
Zentis GmbH & Co. Kg	info@zentis.de

3.6 Inventory Concerns

The inventory consists in materials and products to be used before, in or after the main product manufacture [97].

The main inventory concern is orange peels. These are perishable and need to be processed quickly to avoid mould formation or dried to be processed in a longer time period. The latter option is already practiced by Lara to store orange peels and then sell them to feed producers. The Company will stock the dry orange peels up to 3 years [98].

Pectin powder shelf time is one year in pantry [99]. It can be increased by addition of preservatives. Due to its short shelf life the company will stock only enough PectiCitrus for a 3 month time period based on sales projection in an initial stage. By having a stock of dried orange peels, the company is able process them when a PectiCitrus purchase order is received.

3.6 Key Stakeholders

The bottom line of the company is to satisfy all its stakeholders. This involves the balance of the needs and desires of customers, team members, shareholders, suppliers, communities and the environment while creating value for all. BioADD expects to achieve this goal through:

- → Selling the highest quality natural PectiCitrus
- → Satisfying and delighting customers
- → Supporting team members excellence and welfare
- → Being thoughtful with the community and environment by establishing and practicing clean operational practices
- → Promoting trust and win-win partnerships with suppliers
- → Ensuring integrity, commitment, communication and responsiveness with stakeholders.

However, there are key stakeholders who have the power and interest to support the company's work. As a start up company, it is very important to prioritize the key stakeholders in order to obtain help, both financial and knowledgeable, from key people or organizations. Key stakeholders for BioADD are:

- **FCT-UNL**: the company is a start-up from this University and the team was gathered under the same "*house*". The company wants to enjoy the knowledge and guidance shared by this faculty with its successful start ups. Partnership with FCT-UNL will allow the development of the technology and patent application.
- **Lara Company**: holds a very important place as stakeholder to the company. Several decisions will be met by both companies in order to obtain a successful partnership. The pectin business is dependent upon the commitment and understanding of both companies.
- **IPPA**: The worldwide International Producers Pectin Organization provides several high standards within the pectin Industry that are very important for the company entry in the market and success. The company intends on making part of this association. IPPA co-ordinates the dialogue between international bodies and national regulatory authorities ensuring that Standards and Regulations are fair to both Industry and consumers; warrants that member companies are fully knowledgeable in changes in regulatory requirements at the earliest possible stage; promotes the use of pectin as a safe and effective ingredient; promotes

scientific studies in areas of interest to the pectin industry and shares information on scientific and analytical techniques from independent third parties.

- **Portuguese Government:** BioADD is keen in being supported by the Portuguese government through financial programs. As a stakeholder, the Portuguese government profits from taxes with BioADD as well as the company provides a better sustainable image for the country.
- **Almada City:** BioAdd team founders share a special relation with the Almada City Hall. FCT University campus is established in Almada city, as well as Madan Parque.
- **Algarve Region:** As BioADD factory will be placed inside Lara Company. Lara in turn is built in Sines (Algarve). Algarve City Hall will therefore benefit from space fees that BioADD will pay and also of the sustainable image given by orange wastes reutilization.

Shareholders are of high significance to BioADD as they are an important source of capital. Their money is used to start a business and help to continue its operations. Shareholders also detain a stake in the company which leads them to contribute with innovative and creative ideas to help BioADD grow and increase its market share. It is a strategy of BioADD to associate with stakeholders in order to meet the investment financial needs to start the business. Some of the stakeholders that BioADD will approach are: venture capitals, banks and start-up prizes.. Individual stakeholders will also be approached upon further identification.

4. Business Model

The business model describes the way a company generates revenues by specifying its position in the value chain [90].

4.1 Value Proposition

Partners

Fruit processing companies' costs are generated not only by the treatment of fruit residues but also by storage and transportation. BioADD proposes below a value proposition for these companies to become partners in the business model.

The first partner company will be Lara because it dominates the market of orange processing in Portugal and satisfies the segmentation criteria (see section 3.3.2). Dr. Paulo Duque, personal Manager of Lara, also demonstrated interest in a technology that is able to reduce the costs with orange residues.

Taking into account that Lara Company sells its residues to animal feed for a price of 20€ per ton of residue, BioADD is prepared to offer up to 35 times more profit (that is, 700€ per ton of residue). The proposal is that in four years the partner company profits 50% of the pectin PVP (9 000€ per ton) by providing their residue to BioADD. Also, Lara will receive its share in the second year of BioADD operation (given that this is the year of the breakeven point) and in the end of fourth year of BioADD operation. In the meantime, that money will stay in the bank to be valued.

The offered values per ton includes losses in the landfill opportunity cost (20€/ton) plus fixed costs such as water and rent in their orange processing plant. Lara will endure such costs as a partner in contributing with the space and extra negotiable facilities costs. Future partnership companies will benefit from the same profit conditions, although these are negotiable.

Further detailing according to the financial plan (appendix 5, section 8: In the first year, 25% of Lara residues will be purchased and processed resulting in 315 000€ of revenues (or 8 times more profit than selling the same percentage to animal feed). In the second year, 70% of the residues will be purchased and produced resulting in 882 000€ of profit. In the years of operations 2017 and 2018, the company will buy 100% of Lara orange peel residues, resulting in 1.26 M€ revenues per year (8 times more). Lara's earnings are detailed in the following table 4.1:

Table 4.1 - Revenues for the company Lara

	2015	2016	2017	2018
Price (€/ton)	700	700	700	700
Sold residues	25%	70%	100%	100%
Orange peel residues (ton)	2,000	5,600	8,000	8,000
Lara profit (M€)	0.35	0.88	1.26	1.26
Profit from feed residues sells (M€/ton)	0.04	0.11	0.16	0.16
Profit Ratio (€/ton)	7.87	7.87	7.87	7.87

Source: Dr. Paulo Duque, Personal manager of Lara Company
Notes**:** This table summarizes the revenues for the company Lara The profit value is derived from the company's processing capacity of orange peels in each year (25, 70 and 100%). The profit from feed residue sells considers that Lara profits 20€ per ton of residues sold for that purpose.

BioADD also proposes an environmental responsibility value to its Partner companies. The technology behind pectin production is clean and green. The extraction method is also green and low pollutant. Lara or any future partner company can and should use these benefits in order to obtain a trustful image near its public and clients.

Clients

The company proposes to sell pectin with a high purity degree, safe raw source materials and competitive price to its clients.

Pectin is a valuable sub-product obtained from orange peels using a technology based solely on water. No further solvents are used, thus verifying the secure and green source material. Based on the BioADD's know-how, it is able to provide a safe food ingredient, fulfilling the food industry ingredients requirements.

Distributors clients are able to buy pectin for 4€/Kg, this price being competitive in the market. It is a negotiable value that goes up to 60% of the market price (10€/kg). Distributors can benefit of up to 50% of 9€/kg since this will be the price of PectiCitrus to have a competitive leverage.

PectiCitrus clients can exploit the green status provided by the orange wastes valorization as well as BioADD's water technology. Food consumers currently are focused on natural and biologic source food and ingredients. It is as growing market trend that clients can use in their advantage.

4.2 Market Entry Strategy

The company will enter the market through the creation of a start-up, BioADD. After a year of laboratory pectin and technology scale-up studies at FCT/UNL, BioADD will start to manufacture industrial pectin from orange peels. Profit will be determined by PectiCitrus sales revenues. Several team members are associated with Requimte (green chemistry) laboratory situated in the FCT campus. As a start up company from this laboratory, conducted studies will take place in the pilot scale up laboratory of the university.

PectiCitrus production will follow the "**factory in factory**" business model. This means that BioADD will install all the necessary equipment inside the Fruit Processing Company, as close as possible to the fruit wastes production line. It is assumed that Lara holds the space dimension in the orange processing plant. Staff required to manage reactors and equipments are employed by BioADD as well. The advantages of this strategy are in the decrease of transport costs, proximity with the client and productivity increase. Furthermore, it is possible to negotiate infrastructural and fixed costs aspects to benefit both companies. The goal of BioADD in a partnership is that its partners must provide the space, water and electricity in exchange of the profit already detailed in the value proposition (section 4.1).

BioADD team will be in charge of pectin production and ensure accurate operation of the equipment in order to obtain a high quality product. To pursue this demand, the company will also execute periodic laboratory tests.

The powder PectiCitrus will be sold to European Distributer/Wholesale companies. Distributors with more market knowledge and contacts will buy BioADD' PectiCitrus and sell it to Food Producers. Transportation costs are the responsibility of the client. BioADD will have no more responsibility in selling the product. Therefore, the company is positioned in the Pectin Industry Value Chain as a Pectin Industry Producer (image 4.1).

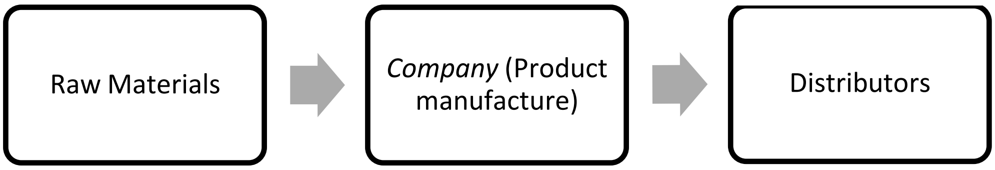


Figure 4.1 - BioADD positioning in Pectin Market Value Chain

After the first four years of partnership with Lara, BioADD will establish new international partnerships. Preferably in growing economies with large orange processing Industries. A potential partnership could be established with Cutrale, the second biggest orange juice maker in the world. Cutrale is located in Brazil and has the advantage of overcoming the language barrier.

5. Intellectual Property

Intellectual property rights are rights held by a person or company to have exclusive privileges to use its own plans, ideas or other intangible assets without the worry of competition. There are two distinct types of intellectual property categories [100]: Industrial Property and Copyright rights. Industrial Property is related to new inventions and includes patents, trademarks, industrial designs, etc.; Copyright includes original creative or artistic work like novels, poems and musical work. BioADD technology and concept falls under Industrial Property and can either be protected with a patent or trade secret. A patent is an exclusive right to commercially exploit the invention in a specific country. The protection is given up to 20 years. Trade secrets involve manufacturing or industrial secrets, commercial secrets and have no time frame of availability [101].

Protection of an idea is important to avoid copies, to ensure market exploitation and obtain financial support. However, its maintenance is an expensive process and application requires very strict criteria.

A patent invention must be **i)** capable of industrial application, **ii)** new and **iii)** detain an inventive step.

- **i)** By industrial application it is understood that the idea must be reproducible;
- **ii)** By novelty, it is understood that the idea is new and there is not information available in any form in the literature: scientific articles, presentations, videos or posters, for example;

iii) The inventive step is the most crucial aspect of submitting a patent because it requires insurance that the idea detains an inventive activity. It means that the idea must not be obvious to an expert in the area.

The question that arises is: can BioADD technology be protected? The answer to it encompasses understanding what previous patents and scientific work is available in literature that can compromise its patentability.

The details of the technology that BioADD will patent are described in chapter 2. It involves valorization of agro-industrial wastes by submitting them to subcritical water extraction technology with moderate temperature and pressure conditions, membranes module purification and drying procedures to finally obtain the product PectiCitrus. This process is achieved in partnership with a fruit processing Company.

To evaluate the possibility of BioADD technology to be patented, a research was conducted with combination of "subcritical water" with "pectin" synonymous, according to appendix 2. The results are positive and promising because no patent matching the production of pectin through BioADD technology was found.

However, several drawbacks were found regarding the innovation and inventive steps as well as the technology itself.

1. The technology presents a patentability challenge because several scientific articles and patents in literature describe its fundaments. They are for example: "*Near critical and supercritical water. Part I. Hydrolytic and hydrothermal processes*" [2], "*Sub- and supercritical fluid extraction of functional ingredients from different natural sources: Plants, food-by-products, algae and microalgae. A review*" [7] and "*Process for The Controlled Liquefaction of a Biomass Feedstock by Treatment by Hot Compressed Water*" patent [103];
2. There are several scientific papers available that question the novelty of the idea. These affect the novelty second step. They are "*Extraction of valuable compounds from the flavedo of Citrus junos using subcritical water*" [21], "*Separation and Characterization of Pectin From Juice Processing Residue Extracted by Sub-critical Water*" [33] and "*Essential oils, pigments, sugar, pectin and cellulose from citrus peel - by extn. with water-miscible organic solvent, aq. dilution of solvent and stripping*" patent [104]. These articles report extraction of pectin from orange peels with subcritical water extraction technology;
3. The third criterion concerning the inventive step is also a challenge because the articles presented next might turn BioADD idea into an obvious one for an

expert in the area: "*Current use of pressurised liquid extraction and subcritical water extraction in environmental analysis*" [10], "*Preparation of Pectin from Fruit Peel of Citrus maxima*" [105] and "*Effect of extraction conditions on some physicochemical characteristics of pectins from 'Améliorée' and 'Mango' mango peels*" [106];

4. There also articles that question BioADD technology innovation of obtaining pectin from citrus peels despite using different extraction technologies. They are: "*Extraction and characterization of pectin from Yuza (Citrus junos) pomace: A comparison of conventional-chemical and combined physical–enzymatic extractions*" [107] and "*Environmentally friendly preparation of pectins from agricultural byproducts and their structural/rheological characterization*" [102].

BioADD will improve the extraction process conditions and technical features. Therefore, reproducibility required in the industrial application criterion is ensured.

To understand how competitors currently protect their businesses, a survey research was made. The results indicate that Danisco, Cargill, CP Kelco and Yantai André Pectin competitors (analysed in section 3.4.2) detain several patents concerning pectin extraction and further standardization procedures. Research results suggest that none of the competitors use the same technology process as BioADD. Appendix 3 presents a list with the main extraction procedure patents by competitor. It is noteworthy the absence of legal patent protection in the Herbstreight & Fox company (among others). It suggests that this company processes are protected by Trade Secret.

BioADD technology concerns specific scale up extraction technical features as well as standardization steps not available in literature. Despite the drawbacks considered above, BioADD technology represents an innovation regarding the full procedure from orange peels to PectiCitrus. Therefore, BioADD patentability is under consideration and requires further research.

BioADD will hire a patent lawyer to help understand the subtleties and to increase the chance of patent acceptance.

6. Marketing Plan

6.1 Vision, Mission and Objectives

Vision

To offer the most sustainable solution for the residue producers.

Mission

To provide the best valorization option for recovery of its organic waste for the producer.

Objectives

The objectives of BioADD are the following:

1. The business purpose is to produce the food ingredient pectin in a powder form to be used in the Food Industry
2. Valorisation of agro-industrial by-products through use of an innovative, sustainable and environmental green technology
3. Market share acquisition through high quality standards and competitive price strategies
4. Strong scientific know-how in team members

6.2 SWOT/TOWS Analysis

The SWOT analysis for pectin production in Portugal, using residues from oranges is presented in table 6.1.

Table 6.1 - SWOT/TOWS Analysis

	Strengths → **Strong scientific know-how and team commitment** → **Green and Safe technology** → **Cheap raw materials** → **Waste residues valorization**	Weaknesses → **New technology under development** → **High supercritical technology implementation costs** → **Seasonality** → **Patent under study** → **People awareness**
Opportunities → Environmental green approach responsibility & trend → Hydrocolloids market growth → European R&D Support → Growing need for residue treatment	**SO (Identification of strategies for advancement)** • Establishment of strategic partnerships with orange processing companies • Acquirement EU R&D support by underlining the environmental sustainable product and technology • Definition of competitive prices strategically used to enter in the growing hydrocolloids market	**WO (Identification of strategies to overcome weaknesses)** • Combination of strong team know-how with technology innovation to deliver patent protection • Through EU R&D support and funding engage in technology development and diminution of costs • European R&D funding to diminish the supercritical technology investment.
Threats → Increasing appearance of new substitutes → Market entrance of competitors → Globalized market with major players	**ST (Identification of strategies to avoid threats)** • Combination of green and environmental features to obtain EU and corporate social responsibility financial support • Faceing new and major competitors with product quality and competitive price • Usage of a clean and safe solvent (water) as opposed to competitors organic solvents	**WT (Identification of strategies to avoid and overcome)** • Establishment of trustful relations with customers in order to maintain long term relations • New partners pursuit and international market penetration • Waste residue valorisation promotion • Continuous innovation in product portfolio • Strong investment in marketing to overcome the low technology awareness in the public

6.3 Marketing Strategy

6.3.1. Product

Features

BioADD will produce PectiCitrus in the form of a high methylated white or light beige transparent powder.

Quality

Food additives must be evaluated for its safety before arriving at the consumer's plate and entering the market. Such evaluation requires the consideration of the probable intake of the additive, the cumulative effect of all uses of the additive and the toxicological tests in order to establish its safety.

Pectin is regarded as *GRAS* (Generally Recognized as Safe) by the FDA (USA Food and Administration Federation). The European Scientific Committee for Food has given Pectin (E440 (i)) and Amidated Pectin (E440 (ii)) the label of not specified ADI (Acceptable Daily Intake) [108]. ADI represents the intake level in humans that may be safely consumed for a lifetime by virtually any member of the population, without health or safety concerns [109]. This means that pectin can be used freely as a food additive without placing any population subgroup consumers in danger. Regulation standards for pectin to be commercialized are set by the European Commission Directive 98/86/EC [108]. These regulations detail the set of conditions for pectin to be industrially produced such as content of galacturonic acid content, solubility and purity. Appendix 4 provides a table with selected conditions guidelines for PectiCitrus enter the food market.

Although BioADD Technology does not alter the constitution and chemistry of pectin, the company will execute the necessary evaluations in order not only to guarantee product safety to its clients in line with the European directives, but as well as to fulfil quality certifications. BioADD guarantees operational quality practices through recruitment of qualified personnel and quality certifications. These last include:

→ **NP EN ISO 22000:2005** – Systems of food safety management; it is a requirement for any organization operating in the food chain [110];

→ **ISO 9001:2008** – International quality management systems. This certification recognizes the effort of the organization to ensure the compliance of their products, customer satisfaction and continuous improvement [111];

→ **FSSC 22000:2010** – Certification developed for the certification of food safety management systems specifically for Food Manufactures.

Furthermore, the company can obtain the following two culture certifications: Halal Certification that determines that pectin can be consumed by Muslins [112], and Kosher Certification that ensures a certain food product can be consumed by Jewish people [97].

BioADD is strongly focused in providing a product with high safety and quality standards to its clients.

Packaging and Design

PectiCitrus is a raw ingredient to be used in food products. Clients expect a practical and functional product ready to be used. With this criteria in mind and aligned with the sustainable technology and product criteria, BioADD will have a rectangular recycled paper packaging. The package features an easy opening and the rectangular shape allows easy storage.

Several of packages will be produced: 1 kg, 2 kg and 50 kg rectangular packages and 100 kg and 200kg sacks, in order to satisfy small and major clients respectively.

The label design will have simple green lines with the logotype, composition and contacts information printed in the recycled paper. The label will also contain the composition, nutritional value and intended use of pectin. In agreement with the sustainable and green strategy of the company plastic labels will not be used.

Guarantee

The company will ensure product replacement if it is not in agreement with quality specifications and within the expiration date.

Logotype & Slogan

Figure 6.1 – PectiCitrus Logotype

The above figure 6.1 represents the PectiCitrus logotype. The use of green shade is

on purpose, in order to underline the concern and commitment to developing green sustainability. The name is a junction of “pectin” plus “citrus” clearly stating that this pectin is derived from citrus fruit peels. The leaf image if an orange tree leaf in clean lines.

Logotype

Valorising everyday wastes into green and sustainable food ingredients.

6.3.2 Price

The offered product has identical characteristics to available competitors. But it differs from the market competitors in its purity degree and innovation. Given the similarities, pricing takes into consideration the price practiced by competitors, partnership costs, sales profit and manufacture costs.

Product Price

Considering fixed and variable costs described and analysed in the financial plan (section 8, appendix 5) 1 Kg of pectin will cost 2.07€. The investment required is 845.570€ and the company expects a payback time in four years. Supercritical technology investment is expensive but this value fades away if sales and volume production are high.

Pricing

BioADD stipulated the price for Distributors. This sort of companies most likely will ask for 50% of the revenues, although this is a negotiable factor. The *company* takes into notice the negotiable aspect as explained in the business model (section 4.1). Therefore the product will be sold at the minimum of 4.5€ per Kg;

Customer Perception of Pricing

Customer perception relates to the perceptions, experiences and subconscious judgements of value that customers have both before and after buying the product. Customers buy a certain product because its price corresponds to the perception of the product value. The value represents the product inherent outstanding features but as well as the customer perception. Customer perception is concluded after comparison with similar products. It is therefore a thin line between overpricing or underpricing pectin or any product/service. The company’s product is a powder similar to its competitors. The remarkable features lie on the waste residue valorization through a clean and green BioADD technology. It is an innovative feature in the pectin industry that is considered in the price.

The company believes that costumer perception of 4€ pricing will be good because clients will get a product with high quality for a competitive price. Despite the fact that PectiCitrus will perform exactly like other branded pectin's, it also has the added value of a green and valorization source. It is then not too expensive because it does not bring a remarkable and unique feature to pectin applications, but also not cheap enough to make customers question its quality.

6.3.3 <u>Place</u>

<u>Distribution</u>

In the marketing mix, the "P" for place discusses how the product is to be delivered to the costumer. BioADD will distribute PectiCitrus through indirect distribution channels.

Indirect Distribution – In this sort of distribution BioADD sells the product to Distributors; one advantage is that Distributors know the specific market in which they operate. Other advantage to the company is the possibility of negotiating pre-payment agreements to ensure the company always has sales and profit. Transportation and storage costs are due to Distributors. The main disadvantage in this sort of distribution is that the decision power lies in the distribution channel. Distributors able to promote the product, establish trust relationships with the costumer and reputation.

BioADD will have a proactive role in personally contacting customers. The goal is to enter the European market through establishment of deals with European Distributor Companies who also operate in the Portuguese market.

The distribution channel must encounter the customer needs. It is very important to the company to gain the costumer trust and not only focus on punctual transactions. BioADD aims to please the costumer.

6.3.4. <u>Promotion</u>

Introduction of a new product in the marker requires a successful promotional campaign strategy in order to achieve its goal. The communication values proposed by BioADD have a focused and personalised strategy as opposed to the traditional broad "spray & pray" one.

<u>Personal selling</u>

To a direct approach to the costumer, BioADD must be direct, credible, and persuasive. Immediate feedback and clarification of any doubts that may arise are also very important features of such approach. The personal selling is a strategy that allows the company to select specific costumer audiences in order to sell its product.

Direct Marketing and Public Relations

Direct Marketing approach facilitates relationship with customers. BioADD will send emails and telephone to specific target customers. Such allows preparation of direct quick messages and answers any doubts effectively. The goal is to ensure the customer trust with the company and product.

Presentation of the product and company to the Pectin and Food Industry is of vital importance. There are several important Food Ingredient conferences and fairs that the company will be attending. From them the company will build a solid network and constantly be updated with news, competitors and new customers. Attendance to the conferences and fairs is dependent on the geography and presence of important potential customers. Three important forthcoming international conferences are Food Ingredients Europe Conference (19-21 November 2013, Frankfurt, Germany), 12^{th} International Hydrocolloids Conference (5-9 May, 2014) and IFT 14 Annual Meeting & Food Expo (location and data not yet determined). BioADD is focused on attending three conferences per year in order to better achieve its goals.

Advertising and Sales Promotion

Divulgation of the product cannot be limited to conferences and fairs. It must reach a larger public. There are several cheap platforms that the start up can use to broadcast its message. They include a website, social networks and specialized magazines and journals.

Website

The website platform is the main tool for the start up to reach its clients. It will have the “factory in factory” business model clearly specified as well as the company’s vision, mission and CEO contacts. The website will feature translation in six languages: Portuguese, English, French, German, Chinese and Spanish. Clients from all around the world will be able to purchase the product online and receive it through terrestrial mail shipping (inside Europe) or air shipping (outside Europe). Clients will place their order and soon after receive the bill. After payment PectiCitrus product will be forwarded. The homepage will feature a clear explanation of the “factory in factory” business model as well as a link where possible companies with organic residues wastes can determine the profit of a partnership with the start up. (Analysed according to the best scenario of the financial plan).

Social Networks

Social Networks allow cheap, easy and widespread promotion. The company will feature a profile similar to the webpage in LinkedIn, Twitter, Facebook, Google +, Wikipedia, etc.. The goal of BioADD is not to advertise immediately in the social networks. The first approach is to talk, connect with other people and potential clients as well as explain the company's values. The bottom line strategy is to gain trust and be seen as a know-how leader. The public view of the company as a sustainable one is very important for and to support its green status image.

Press

Another key to the company and product divulgation strategy is through the press. Such includes advertising in hydrocolloids and food ingredients magazines as well as in renowned journals in the same areas. The most important general ones are Food Hydrocolloids, Journal of Food Science, Food Processing, Journal of Agricultural and Food Science.

7. Development and Operations Plan

7.1 <u>Prototype to Finish Product</u>

To obtain a product ready to be marketed several aspects must be taken into consideration while developing the prototype. The prototype englobes the BioADD technology and PectiCitrus product study. BioADD technology is new in the market and will probably need a year to be studied in order to put de product in the market. Below is discussed the main aspects to take into account.

A group of investigators were able to extract pectin from citrus peels. Hence, there is a proof of concept available in literature verifying that BioADD technology can be used to produce PectiCitrus. Nevertheless, further tests are required to **i)** assess the optimal and efficient PectiCitrus extraction conditions, **ii)** determine and optimize the BioADD technology scale up procedure and **iii)** perform laboratory quality, product line development and standardization tests.

i) and **ii)** BioADD will perform tests in order to determine the best efficient product extraction and technology scale up conditions. Scale up is the procedure that allows to move from laboratory scale into pilot and finally into the industrial level. It presents a number of process, equipment design and technology risks that will be reduced to the minimum during the year of investigation and development. The extraction conditions achieved, refered in literature [3] [4] are predetermined for a small reactor that holds small ammounts of raw material (0.5g and 7.0 ml capacity). BioADD will produce much more quantity of pectin. It requires a reactor with 471 l volume capacity to process 8000 tons of residues per year. Studies will be carried to determine the optimal conditions of operation that is the best temperature and pressure conditions that allow the fastest pectin extraction without quality loss.

iii) PectiCitrus product must be in accordance to quality and safety legislation in order to be used by the food Industry. BioADD will perform intern tests to guarantee the best quality and a credited independent laboratory will then validate them. The PectiCitrus obtained directly from extraction also needs to be further studied. This study intents to understand the next operational conditions to convert it into a sellable product ready to be used in different food applications. This will translate into a product line development whose differential characteristics are quantity of sugar, pH, setting time, and solid contents.

The final stage of manufacture is to pack the PectiCitrus powder into paper packages, ready to be sold to the Food Industry.

7.2 <u>Infrastructure</u>

BioADD will require equipment for the headquarters office and product manufacture.

In the office, the team will need common office equipment like tables, chairs, cell phone and portable computers. Tables and chairs are provided by Madan Parque. This incubator also supplies printing/copying installation but for a tabled value.

In product manufacture the operational team members will require an appropriate protective outfit, protective eye glasses, gloves and a box tool. The machinery required to assemble the factory is:

→ Two tanks to store raw material and final product;
→ Transporter
→ Pump
→ Crusher
→ Reactor
→ Membranes module
→ Evaporator

7.4 <u>Geographical Location</u>

BioAdd Headquarters is located in Madan Parque, which in turn is located in Almada city in the district of Setúbal. The BioADD factory is located inside Lara Company in Silves, Algarve. Figures X shows a map representation of the geographical location of BioADD.

Figure 7.1 – Geographical location of BioADD in Continental Portugal

8. Financial Plan

BioADD's financial plan is projected for five years (appendix 5). Both technology and product will be further developed and analysed in the first year of the start up company in FCT-UNL and a patent will be submitted in the same time frame. Commercialization of the product starts on the second year, 2015. The projections estimated in this financial plan are approximate values and not precise ones.

8.1 <u>Revenues</u>

Revenues are derived from the sales of PectiCitrus, either online or through Distributors. Pectin is a food ingredient and a commodity product. Its demand and supply are part of a large universal market; therefore the company believes there will be clients to absorb the production. Also, the price charged (4.5€/Kg) is a competitive one and ensures product flow (pectin market price is 10€/Kg). Projection of sales and revenues is esteemed in table 8.1:

Table 8.1 - Sales and Revenues Forecast of BioADD during five years of activity

	2014	2015	2016	2017	2018
Sales (ton)	0	450,00	1.260,00	1.800,00	1.800,00
Revenues (M€)	0	2.02	5.67	8.10	8.10

<u>Sales Forecast</u>

In **2014** there will be no sales or income. During this year BioADD will develop the SW technology scale up method and perform safety ingredient tests in order to obtain food quality certifications (section 6.3.1). All these laboratory tests will be made at the Requimte laboratory facilities in FCT-UNL. Laboratory proof of concepts will also be met in order to submit an international patent and obtain financial support. Accreditation and validation of the patent by the competent authorities will ensure commercialization of the high quality product at a safe level.

2015 marks the outset of pectin production and market commercialization. The scale-up technology procedure will be reached and suitable to Lara's facilities. In the first year of operation BioADD produces 25% of total production, resulting in 2.02 million euros of revenues. The goal is to conquer 1% of the European pectin market and 1.8% of the European jams, jellies and marmalades, Soft drinks and Yoghurts and acidified milk drinks market.

In **2016**, the company expects to produce 75% of the total capacity, resulting in 6.75 million euros of revenues. The increase of production will be due to the efforts and marketing strategies of the company outlined in section 6.3 as well as the strategy of conquering plus 2% of the European pectin market. The pectin produced during this year is able to fully satisfy the Portuguese pectin market need (1127 tons) and 5% of the three European food segments.

In **2017** and subsequent year, production will be at its highest value with sales reaching 1800 tons of pectin and 8.1 million euros profits. At this stage, BioADD will conquer 4% of the European pectin market and 8% of the three target food markets. To ensure sale of all raw material in stock, the company will negotiate contracts with worldwide Distributors.

The maximum production achieved in partnership with Lara covers 80% of the potential Portuguese pectin market in 2018 (1433 tons, section 3.3.1) and represents 4% of the forecasted European market (47309 tons) in the same period.

The maximum pectin production achieved is enough to cover all Portuguese target food markets (760 tons).

The partnership with Lara will be maintained after five years, if such interests both companies; but in this time frame the company will also be focused in reaching new potential profitable partnerships.

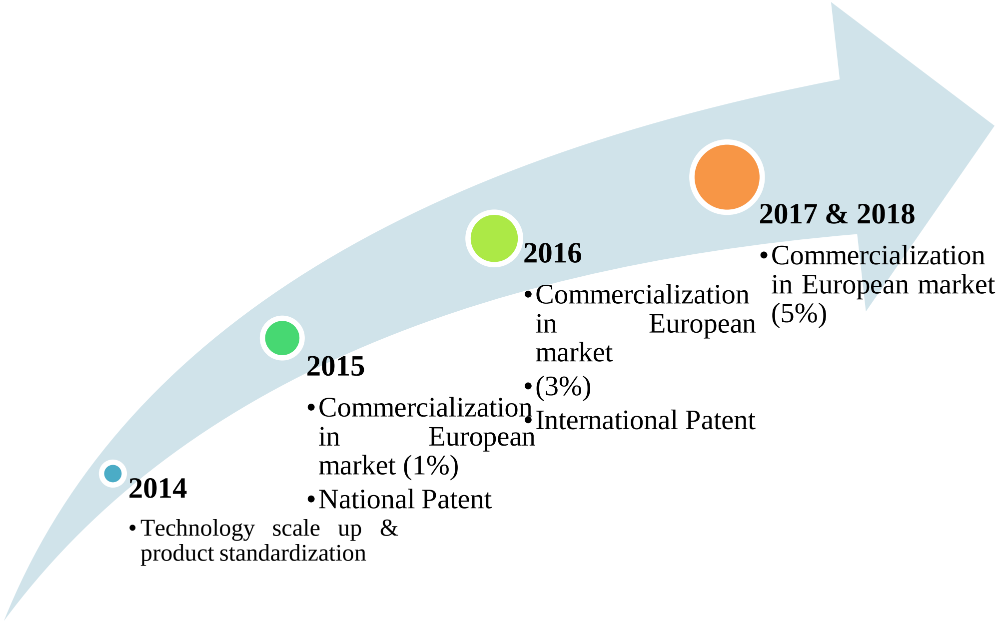


Figure 8.0.1 – Timeline for the activities and market goals of BioADD

8.2 Expenses

This subchapter considers several company activity expenses and suppositions for the duration of five years. They are presented in table 8.2.

Table 8.2 - BioADD expenses during five years of its activity

	2014	2015	2016	2017	2018
Equipment	762,870	-	-	-	-
Industrial Property	-	7,700	-	-	-
Research & Development	75,000	-	-	-	-
Accountability	0	2,400	2,400	2,400	2,400
Patent Lawyer	-	2,000	-	-	-
Office Rent	-	2,400	2,400	2,400	2,400.00
Conferences	-	14,000	14,000	14,000	14,000
Website design	-	2000	-	-	-
Human Resources	0	79,340	79,340	111,717	111,717
Total (€)	837,870	28,500	18,800	18,800	18,800

Equipment

The major expense for the company is the initial investment, which is made in equipment, 762 870 €. This investment will be met in the first year of operations. Equipment expenses are subdivided in two categories: a) direct costs and b) indirect costs. The first is also divided in main parts comprising the machinery indispensable for the production process (reactor, tanks, pumps, evaporator, shredder, etc) and b) the coupling expenses comprising piping and electrical installations to connect all individual machinery. A detailed analysis of the equipment expenses is presented in table 8.3.

Table 8.3 - Costs of the equipment required for the business activity of BioADD

Direct Costs (€)	**Main Parts**	Tank	15,000
		Transporter	15,000
		Pump	10,500
		Crusher	10,000
		Reactor	50,000
		Membranes module	50,000
		Evaporator	50,000
		Tank	15,000
	Coupling	Piping	146,540
		Electrical Instalation	23,705
		Instalation	101,285
		Utilities	172,400
Indirect Costs (€)		Licenses	8,620
		Contingencies	94,820
Total Equipment (€)			762,870

Industrial Property and Patent Lawyer

A Portuguese and International patent will be submitted in the second year of activity. IP expenses are 1200€ and 6500€, respectively. To ensure proper writing and regulations of the patent, a patent lawyer will be reached in the same year.

Research & Development

Costs associated with technology and product development are 75 000€. Research will take place in partnership with the laboratory Requimte at FCT-UNL. This expense is an approximation and considers the costs of materials, reagents and salary of two persons: CEO and Researcher for the duration of a year.

Accountability

The company will hire an accountant starting in the first year of operations, 2015. The expenses associated with the accountant are 2400€ per year.

Office Rent

During the first year of activity, BioADD will not have an office because its Human Resources will be focused in developing the technology in Requimte laboratory. The company will establish an office in Madan Parque facilities due to the proximity and special relationship with FCT-UNL. This is a technology and company incubator that provides several important services like office equipment, internet, electricity, mailbox, secretary and security services, etc., for the value of 200€ per month.

Conferences

The strategy of the company is to attend three conferences per year in order to publicize both product and company (section 6.3.4). The associated expenses are esteemed to be 4000€ per conference and includes travelling, conference expenses, illuminated stands and accommodations. Further expenses are necessary for business cards, leaflets and catalogues totalling 2000€ per year. The mentioned values are suppositions and are not supported by real data.

Website design

The website is one of the most important tools to divulge the company and product. There are several available companies and platforms where the company will set up the website according to chapter 6 specifications. The esteemed value for the website design is 2000€.

Human Resources

The salaries of the human resources (table 8.4) consider the salary base during 14 months, the social security percentage and work accident insurance. These values are based in the *Investidor* webpage [113]. In 2014 the company will have a CEO and an Investigator as human resources doing the research and development of the technology and product. They're salaries is accounted in the Research & Development investment above mentioned.

The start of production in 2015 requires increase in staff, specifically five operators and one more investigator. This is the team that constitutes the company human resources. The operator will earn 900 €/month, Investigators 1200 €/month and the CEO 3000€/month. Salaries will increase 3% per year. It is important for BioADD to have an experienced commercial that is knowledgeable about the Food Industry. Such a person would cost far more that 1100€ per month. However, BioADD is ready to propose a partnership in the company and hence the comercial will profit with BioADD sales gains.

Table 8.4 – BioADD Human Resources expenses

	Number	Salary	2014	2015	2016	2017	2018
CEO	1	3,000	0.00	53,755.00	55,367.65	57,028.68	58,739.54
Investigators	2	1,200	0.00	43,234.00	44,531.02	45,866.95	47,242.96
Comercial	1	1,100	0.00	20,438.50	21,051.66	21,051.66	22,333.70
Operators	5	900	0.00	80,057.50	82,459.23	84,933.00	87,480.99
Total	8	6,200	0.00	21,648.20	21,648.20	24,134.32	24,134.32

8.3 Pay-back period

BioADD investment is determined by the equipment expenses, costs associated with equipment installations and Intellectual Property expenses, totalizing 770 570€ (table 8.5).

BioADD CEO and some elements of the team will cover the initial research costs by personal funds and funding of friends and family. In spite of being a very high investment, it was assumed that investors, business angels and stakeholders will pay the remaining investment in the first year of the company.

Table 8.5 - Total Investment required for BioADD business activity

	Investment
Equipment	**762,870**
Research & Development	75,000
Intelectual Property	7,700
Total of Investment (€)	**845,570**

Regarding Industrial Property, since the technology was and will be developed in FCT-UNL, the intellectual rights belong to the University. However, BioADD beliefs that the University will grant these rights to BioADD in exchange for the permanent name association with this institution.

BioADD breakeven point will occur at the third year, that is, when the company will cease to have prejudice. The Internal Rate of Return (IRR) is stipulated in 32.05% per year, during five years and the period of return on investment is three years.

8.4 Exit Strategy

The exit strategy of BioADD is to sell the company in 2018, after five years of business.

9. Team

BioADD team is the key to the success of this business plan. Commitment, motivation, knowledge expertise and team work is the key features that BioADD quests for in its team. The combination of these features will allow having a workforce focused on success and working proactively to reach it.

The workforce required for the development of BioADD business is divided into two stages. The first stage takes place during the first year where two people are required for BioADD technology development. Both need to possess great knowledge in supercritical fluids technology as well as laboratory skills. This is primordial in order to meet the goal of starting operations and PectiCitrus commercialization in the second year of activity. The second stage begins in the second year of BiotADD's activity with production and commercialization. It is necessary to hire more workforces to be divided in the following BioADD departments presented in the BioADD organogram (figure 9.1):

Figure 9.1 – BioADD Organogram

Research and Production

The task of Research and production team is to meet the needs of tomorrow's consumers anticipating and satisfying those customers. This department gathers both the investigators as well as the operators' workforce. Investigators must meet technology and laboratory skills because they perform quality tests and are responsible for research. It is also highly important that operators detain supercritical fluids knowledge because they will be the ones directly working and responsible for the PectiCitrus manufacture.

Marketing and Sales

For the department of marketing and sales, BioADD requires a person with expertise and knowledge in the ingredients food sector. BioADD is interested in hiring a commercial that previously worked for a reasonable amount of time in the area and holds a positive respect in the field. This person will be responsible for the promotion, divulgation and product sales in the market. It is extremely important to have a person with communication skills and capable of understand the product and technology.

Project Management

To meet project requirements BioADD requires a person with leadership, coordination and organization skills. It is vital to have someone in charge of meeting daily demands and inspiring co-workers on a daily basis. This person is responsible for ensuring that all aspects of the project life cycle are covered. The best nominate to occupy the project management department is the BioADD CEO.

Finances

The Finances department should be in the hands of a person with certified financial management skills. The importance of this department is for BioADD to present a stable and positive financial feedback. An accountant will be hired by BioADD who will be constantly aware of the company financials and treat them monthly. The accountant can either be a freelancer or a part of an accountant firm.

10. Critical Risks

This chapter considers the key threats to the business and company. One of the major risks for BioADD is the low PectiCitrus shelf time period of a year. To overcome this hindrance the company will stock of the product for about three period month time according to sales prevision. Also, the company will stay focused on acquiring customers.

Another risk is the possibility of bad environmental and agriculture conditions occur and orange trees plantation be conditioned for a given period. The raw material is orange peels and hence BioADD could negatively see the result in lower revenues and higher maintenance costs. However, BioADD can stock dry orange peels and avoid a major negative situation.

The possibility of not acquiring the needed investment for the research and product development period must be faced. If investors do not show interest in financing these costs, then the company must search for prizes and entrepreneurship competitions in order to fulfil them; however, there is also the risk of not obtaining enough funds through these. In another hand, regarding the product, there is small evidence in the market that pectin can indeed be safely produced with SW Technology and a prototype is not available. BioADD can mitigate the later risk through a proof of concept in which it will produce pectin with the technology and perform safe tests warranted in regulati**o**ns as soon as possible.

There is the risk of not being able to compete in the pectin market. The competitive prices strategy is developed to overcome this obstacle; however, multinational major players may offer lower prices if they feel threatened even considering that the company will act in three target food markets.

Sales projection failure is a possible risk for the company and shareholders. Sales are supported by the market size and its expected growth; nevertheless it is uncertain if customers will effectively buy the product. Sales projections are associated to an error margin.

Another critical risk is the possibility of not being able to obtain a patent. A patent at the beginner stage of the company is a valuable asset to ensure market prospective entrance and compete with other pectin manufacturers. If this possibility cannot be reached, then BioADD will opt for the Trade Secret as means to protect its technology.

11. Conclusion

There are several market applications for SW Technology. Biomass wastes constitute large under-exploited residues; they present endless appealing market applications given the heterogeneity in nature. However, not all detain the conditions necessary to be transferred from the laboratory into the market. Production of PectiCitrus from industrial orange residues was the idea considered most attractive. The goal is to produce PectiCitrus to be used in the Food Industry, more specifically in the Soft Drinks, Yoghurts and acidified milk drinks and Jams, jellies and marmalades

BioADD start-up is composed of committed and knowledgeable team elements that look forward for the success of the company. BioADD will establish a partnership with Lara, located in Algarve, in order to use its orange residues for the production of PectiCitrus. The business model strategy is *factory in factory*. This strategy is advantageous not only for BioADD (l) but as well as for Lara; by using their facilities space and other agreed conditions, Lara will profit 35 more times than with the current residue disposal for animal feed and benefit with a green and sustainable status image.

Literature presents a *proof of concept* for the production of pectin with SW technology. However, the team elements with great expertise and *know-how* will perform scale up investigations in order to adapt the technology to the volume of waste residues available. Further studies regarding standardization and quality control of PectiCitrus will also be required in order to ensure the best product as possible. These stages will take place in an early stage of the BioADD creation (first year of BioADD company creation).

Combination of team supercritical fluids know how, competitive price and sustainability with the technology innovation in the pectin Industry has the company positioned to claim a solid spot in the market. Traditional pectin manufacturers employ methods that require the use of flammable, toxic and environmental harmful solvents. On the contrary, BioADD only employs water that is the safest environmental and healthy solvent. In another hand, BioADD is able to provide a competitive product with the same quality, if not better, than its competitors.

Awareness of food ingredients provenience and concern with non Natural sources is an increasingly market trend and healthy preoccupation from Food consumers. With PectiCitrus, Food Producers will be able to satisfy this growing trend and demand by providing a product with sustainable, natural and green characteristics. Food Producers have the chance to offer healthy options to their clients by purchasing the same quality pectin for a very competitive product in the market.

In partnership with Lara, BioADD has the potential to produce 1800 tons of PectiCitrus. The Portuguese pectin market is estimated in 1127 tons (11 M€) and the European pectin market in 37 191 tons (372 M€). BioADD will target three major Food market segments mentioned above that constitute 67% and 76% of the Portuguese and European market, respectively. BioADD will target the European market in order to enter a bigger market and ensure sale of all production capacity. In the first year the goal is to acquire 1% of the EU market, followed by a 1% growth during 4 years. BioADD expects to dominate a market of 14 M€ by the end of the fifth year.

The Internal Rate of Return (IRR) is stipulated in 32.05% per year, during five years and the period of return on investment is three years. BioADD breakeven point will occur in the third year.

The initial start-up capital investment is stipulated in 850 000€. BioADD technology is an expensive technology in terms of equipment. These need to be strong and safe. Team members are prepared to cover the Research & Development costs (75 000€) and Industrial Property (7 700€). The remaining investment will be faced by business angels and venture capital.

Regarding patentability of PectiCitrus market application, it is of importance for BioADD in order to acquire a competitive leverage in the market. The conducted research indicated the absence of a patent that transforms orange peel wastes into HM Pectin through Subcritical Water Extraction like BioADD does. It may be possible to patent this application but more detailed studies should be conducted.

BioADD is a company focused on providing the best quality and sustainable products for its customers by valorization of biomass residues with green technologies. The future vision of the company is to be able to provide different environmentally friendly products and further valorize the biomass. BioADD hopes to contribute to a more sustainable future. Regarding PectiCitrus application, BioADD expects to continue to grow in the Pectin Industry by establishing profitable partnerships with fruit processing companies who face similar conditions like Lara and also by providing worldwide online sales in a near future.

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Appendixes

Appendix 1

Table 1.1 – List of Contacts

Company	Name	Contact	Theme
SUCH	Maria José Grafanhate	suchambiente@such.pt	Hospital residues waste treatment
Initial Medical Services	Engª Sonia Almeida	sonia.almeida@rentokil-initial.com	Hospital residues waste treatment
Egeo	-	-	Collection and transport of hospital waste, industrial waste treatment
Solmirco Laboratórios	Dra. Estela Ramos	solmirco@solmirco.pt	Wholesale and Nutraceutics, Supplements and Dermo Cosmetics Laboratory
Casa Mateus	Emily Rodrigues	casadamateus@casademateus.pt	Quantity of pectin in Jams and pectin suppliers
Hero Portugal	-	hero.portugal@hero.pt	Quantity of pectin in Jams and pectin suppliers
Casa de Lucena	-	info@casalucena.pt	Quantity of pectin in Jams and pectin suppliers
Unilever	-	foodsolutions.portugal@unilever.com	Quantity of pectin in Jams and pectin suppliers
Casa da Prisca	-	geral@casadaprisca.com	Quantity of pectin in Jams and pectin suppliers
Oficina dos Doces	Clarice	-	Quantity of pectin in Jams and pectin suppliers
Nestlé Portugal	-	faleconnosco@pt.nestle.com	Target pectin consumer - Quantity of pectin in yoghurts
Danone Portugal	Natália Janela	matalia.janela@danone.com	Target pectin consumer - Quantity of pectin in yoghurts

Company	Name	Contact	Theme
Mimosa	Suzana Silva	marketing@lactogal.pt	Target pectin consumer - Quantity of pectin in yoghurts
Herbstreith & Fox	Hans-Ulrich Endress	h.u.endress@herbstreith-fox.de	Quantity of pectin produced, distributors and market price
Calleva	Natasha Meadows	info@calleva.uk.com	Quantity of pectin produced, distributors and market price
Naturex	Olga Pardo Caride	naturex@naturex.com	Quantity of pectin produced, distributors and market price
Ceamsa	-	camsa@ceamsa.com	Quantity of pectin produced and market price
Cargill	-	cargill_info@cargill.com	Quantity of pectin produced and market price
Geloados Olá	-	linha.ola@unilever.com	Target pectin consumer - Quantity of pectin in Ice creams
Infarmed	-	cimi@infarmed.pt	Pharmaceutical products containing pectin
F. Lima SA	Sofia Gonçalvez	sofia.goncalves@flima.pt	Distributor of Pectigel by Diese in Portugal
Brenntag Ibéria	Susana Silva	SUSANA.SILVA@brenntag.pt	Distributor of Pectin in Portugal and Europe
Inofruta	Pedro Oliveira	-	Fruit processing company - quantity of residues produced
Lara	Paulo Duque	pduque@cutrale.pt	Fruit processing company - quantity of residues produced
Decorgel	-	-	Yoghurt Portuguese manufacturor
Nutrigreen	Mariana Pereira	mariana.pereira@nurigreen .pt	Fruit processing company - quantity of residues produced

Appendix 2

Appendix 2.1 – Industrial Property research keywords

Synonymous for Subcritical Water Technology	Synonymous for pectin
• Subcritical water extraction • Subcritical water • Pressurized hot water • Hydrothermal liquefaction • Subcritical fluid • Sub-critical water • Hot compressed water • Near-critical water	• Pectin • Galacturonic acid

Appendix 3

Appendix 3.1 – Industrial Pectin Production Patents of competitors

Applicants	Patent Number	Date	Patent Name
Danisco	US6855363	15-02-2005	Methods of obtaining selected pectin fractions, such fractions and their use [114]
Cargill	US2009110798	30-04-2009	Process for Obtaining Pectin [115]
CP Kelco	WO2012167963	13-12-2012	Process for Extraction of Pectin [116]

Source: Espacenet

Notes: The patents presented are the ones more related to BioADD idea in terms of producing pectin. All competitor companies detain several patents concerning pectin standardization, obtention of LM and Amidated pectin as well as pectin applications (in food and pharmaceutics)

Appendix 4

Appendix 4.1 – Regulations for Purity Requirements of Pectin

International Specification	EU E440 (i) Pectin	EU E440 (ii) amidated Pectin	FAO/WHO JEFCA Pectins	FDA/FCC Pectins	USP Pectin
1. Loss on Drying	max. 12%	max. 12%	max. 12%	max. 12%	max. 10.0%
2. Acid-Insoluble ash (in approx. 3N HCl)	max. 1%	max. 1%	max. 1%	max. 1%	-
3. Total Insolubles	max. 3%	max. 3%	max. 3%	max. 3%	-
4. Sodium methyl sulfate	-	-	-	max 0.1%	-
5. Free methyl-, esthyl- or isopropyl alcohol	max. 1%	max. 1%	max. 1%	max 1.0%	max. 1%
	on the anhydrous basis		-	-	-
6. Sulphur dioxide	max. 50 ppm	max. 50 ppm	max. 50 ppm	max. 50 ppm	max. 50 ppm
	on the anhydrous basis		-	-	-
7. Nitrogen content (pecitns) (after washing with acid and ethanol)	max 1.0%	-	max. 2.5%	-	
8. Nitrogen content (amidated pectins) (after washing with acid and ethanol)	-	max. 2.5%	max. 2.5%	-	-
9. Galacturonic acid (on the ash-free and anhydrous basis)	min. 65%	min. 65%	min. 65%	min. 65.0%	min. 74.0%
10. Degree of amidation (amidated pectin)	-	max. 25%	max. 25%	max. 25%	-
11. Sugar and organic acids	-	-	-	-	max. 16%
12. Arsenic	max. 3 ppm	max. 3 ppm			max. 3 ppm
13. Lead	max. 5 ppm	max. 5 ppm	max. 5 ppm	max. 5 ppm	max. 5 ppm
1. Cadmium	max. 1 ppm	max. 1 ppm	-	-	-
15. Mercury	max. 1 ppm	max. 1 ppm	-	-	-
16. Total aerobic microbial count yeast and molds	-	-	-	-	max. 1,000 CFU/g
	-	-	-	-	max. 100 CFU/g
17. Pathogenous germs	according to general food regulations				
18. Pesticides	according to general food regulations				

Source: Herbtreight & Fox

Notes: EU = European Union, FAO/WHO = Food & Agriculture Organisation / World Health Org., JEFCA = Joint Expert Committee on Food Additives, USP = United States Pharmacopeia, FDA = Food and Drug Administration, FCC = Food Chemical Codex

Appendix 5

Appendix 5.1 – BioADD Financial Plan

BioADD Financial Plan					
Investment	**2014**	**2015**	**2016**	**2017**	**2018**
Intangible Assets					
Expenses with facilities	103,440	0	0	0	0
Research and development	75,000	0	0	0	0
Industrial Property	0	7.700,00	0	0	0
Tangible Assets					
Equipment	659,430	0	0	0	0
Total Investment	**837,870**	**7,700**	**0**	**0**	**0**

Revenues and Expenses	**2014**	**2015**	**2016**	**2017**	**2018**
Sales Revenues					
Quantity sold (ton)	0	450	1,260	1,800	1,800
Unit price (€/ton)	0	4,500	4,500	4,500	4,500
Total Revenues	**0**	**2,025,000**	**5,670,000**	**8,100,000**	**8,100,000**
Costs (€)					
Raw material	0	315,000	882,000	1,260,000	11,260,000
Office rent	0	2,400	2,400	2,400	2,400
Marketing	0	16,000	14,000	14,000	14,000
Electricity, Water, Accounting, Advocacy	0	1,651,111	1,651,111	1,651,111	1,651,111
Total Costs	**0**	**1,984,511**	**2,547,511**	**2,925,511**	**2,925,511**
Humman Resources (anual)					
CEO	0	53,755	55,367	57,028	58,739
Commercial	0	20,438	21,051	21,683	22,333,
2 Investigators	0	43,234	44,531	45,866	47,242
5 Operators	0	80,057	82,459	84,933	87,480
Income tax (12% of the salarydo salário)	0	23,698	24,409	25,141	25,895
Total costs	**0**	**221,183**	**227,818**	**234,653**	**241,692**
Total Expenses	**0**	**2,205,694**	**2,775,329**	**3,160,164**	**3,167,203**

Análise financeira	**2014**	**2015**	**2016**	**2017**	**2018**
Gross Profit	0	1,710,000	4,788,000	6,840,000	6,840,000
EBITDA	0	-180,694	2,894,670	4,939,835	4,932,796
Depreciation and Amortization	0	127.697	127,697	127,697	127,697
Earnings before Tax	0	-308,391	2,766,972	4,812,138	4,805,098
Tas losses	0	0	308,391.71	0	0
Income before tax	0	0	3,075,364	4,812,138	4,805,098
Corporate Tax (25%)	0	0	768,841	1,203,034	1,201,274
Net Profit	0	-308,391	1,998,131	3,609,103	3,603,823
Cash Flow from Operations	0	-180,694	2,125,829	3,736,801	3,731,521
Working capital requirement	0	-570,000	-1,596,000	-2,280,000	-2,280,000
Investment	**-845,570**	**0**	**0**	**0**	**0**
Free Cash Flow	**-845,570**	**-750,694**	**529,829**	**1,456,801**	**1,451,521**

VAL (valor actual líquido) @ 15%	**690.06 €**
TIR (taxa interna de rendibilidade)	**32.05%**
Período de retorno do investimento	**3 years**