SAMPLE REPORT

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WRITTEN BY

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BIODEGRADABLE FOOD PACKAGING:
AN ENVIRONMENTAL IMPERATIVE

A niche market grows as economic forces converge

IN THIS SAMPLE REPORT

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EXECUTIVE SUMMARY

Most of our food comes from Nature, and in the future, more of its packaging is likely to be bio-based, as well. Currently, biodegradable packaging is a niche market, about one to two percent of the food packaging segment, which accounts for about 40 percent of the $460 billion global packaging industry. Currently, only a few companies are producing biodegradable packaging materials on a large enough scale to be commercially successful. According to one estimate, biodegradable packaging will see 20 percent annual growth between 2005 and 2010. Even so, it will continue to be only a small fraction of the overall food packaging market.

The primary factors driving development of the biodegradable packaging market include the increase in crude oil prices, which has narrowed the price differential; consumer demand; the proliferation of convenience packaging; development of new applications for bioplastics; increased economic viability as production ramps up and unit costs decrease, and development of the composting infrastructure for optimal disposal of bioplastic products.

New technologies using renewable plant materials as a biodegradable food packaging are being explored and patented. Biodegradable packaging is being manufactured from refuse such as sugar cane waste and other sustainable plant byproducts, including corn, potatoes and bamboo. These materials do not produce environmentally harmful byproducts, and they are non-toxic and biodegradable, often decomposing within just a few weeks, if they are disposed of under appropriate conditions.

Potatoes and corn dominate the biodegradable food packaging patent landscape. However, aside from the moral argument against diverting food crops to industrial uses, increasing demands on corn production for biofuels, while good for the farming industry, has resulted in increased prices that could alter the economics that make its long-term utility as a polymer for packaging questionable. Agricultural waste products show promise and avoid controversial moralism.

Even so, consumer demand for products that are environmentally friendly, safer and nontoxic, as well as a currently favorable economic scenario leads to the conclusion that biodegradable packaging products will become increasingly popular.

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MARKET BACKGROUND

Walter Brooke (Mr. McGuire): I just wanna say one word to you. Just one word.
Dustin Hoffman (Ben Braddock): Yes, sir.
Walter Brooke (Mr. McGuire): Are you listening?
Dustin Hoffman (Ben): Yes, I am.
Walter Brooke (Mr. McGuire): "Plastics."

This exchange from the 1967 movie The Graduate was intended as a spoof but ended up being prescient about an industry that has rarely had to look back. Until now. A trend is beginning to emerge away from plastics such as petroleum-based PET (polyethylene terephthalate) and toward materials such as PLA (polylactic acid), a starch derivative that can be produced from corn and other high-starch plants, and PHA (polyhydroxyalkanoates), which are produced by using renewable carbon sources, such as sugars, plant oils and bio-waste.

Still, the biopolymer market is starting from an extremely small base. According to the Rapra Technology market report titled, “Biodegradable Polymers,” bioplastics accounted for just 0.14 percent of Western Europe’s total thermoplastics consumption in 2005. And the EU accounts for 59 percent of the global polymer market, as compared to North America at 22 percent and Asia at 19 percent. The German manufacturer BASF predicts that even at 20 percent annual growth the market segment is likely to remain small over the next five years. Freedonia, an international business research firm, predicts that biodegradable plastics have the potential of gaining 20 percent of the overall plastics market over time.

Economically, biodegradable packaging products are becoming competitive with petroleum-based plastics. Food packagers using conventional plastics are facing price increases of 30 percent to as high as 80 percent due to rising petroleum prices, according to a report in Food Production Daily. Dirk Carrez, director of public policy for industrial biotechnology at EuropaBio, told Chemistry World in a November 2005 article that biomass becomes competitive for making chemicals when oil reaches $55 a barrel or more. He predicted that by 2010, biomass would be competitive at $40-45 a barrel. With oil prices regularly topping $60 a barrel, it appears that bioplastics have reached that threshold.

The number of bioplastic manufacturers and production capacities are increasing, which could lead to more competitive pricing as compared to petroleum-based plastics. One report predicts that based on public announcements, the current capacity of about 360,000 tons annually will increase to 600,000 tons by 2008. Additionally, advances in technology have created materials better suited to compete with oil-based plastics, and major packaging companies worldwide are beginning to produce a wider range of biodegradable products:

- Amcor and Plantic Technologies developed flexible packaging for confectionary applications.
- NatureWorks, a division of Cargill, introduced a corn-based polylactic acid (PLA) that is price competitive with petroleum-based PETs, leading to a 170 percent sales increase in 2005. The company is now developing a new PLA that can be used for microwavable packaging.
- Hycail is launching a new PLA that will not distort at temperatures up to 200 degrees Celsius.

- Stanelco is developing a biopolymer that will be less expensive than PET but with similar processing qualities.
- Danisco produced a colorless, odorless plasticizer from castor oil and acetic acid.
- InnoWare launched a new line as part of its Eco-Line brand, using a thermoformed packaging developed by Cereplast.
- BASF announced it would finance research at Graz University of Technology in Austria to find ways to decrease biopolymer production costs to make them more competitive.
- ADM and Metabolix formed a joint venture called Telles to build a bioplastics plant in Iowa, which should produce 50,000 tons annually by 2008.
- Toyota constructed a 1,000-ton capacity pilot plant to produce PLA's, predicting a global market for bioplastics totaling $38 billion annually.
- Gilbreth Packaging, in partnership with Plastic Suppliers, became the first to offer biodegradable, corn-based PLA shrink labels made from Earthfirst films.

On the demand side, several recent events are noteworthy when considering the potential of biodegradable packaging.

- Wal-Mart announced plans to replace traditional plastic packaging with biodegradable packing for fresh produce.
- Sainsbury's, a leading British supermarket chain, said it intends to use biopackaging for 500 product lines eventually replacing 4,000 tons of petroleum-based packaging annually.
- The U.S. Department of Agriculture published guidelines giving regulatory preference to bio-based products.
- The Greenery, a leading European vegetable and fruit distributor, announced plans to convert its conventional packaging to biodegradable packaging.

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WHAT RECENT PATENT ACTIVITY SUGGESTS

The technology surrounding biopolymers and biodegradable packaging has been in the development stage for the last 15-20 years. But in only the last five years have markets developed and much commercial growth been seen. New technologies using renewable plant materials in biodegradable food packaging are being explored and patented, but only a few companies are currently producing biodegradable packaging materials on a large enough scale to be commercially successful.

Figure 1

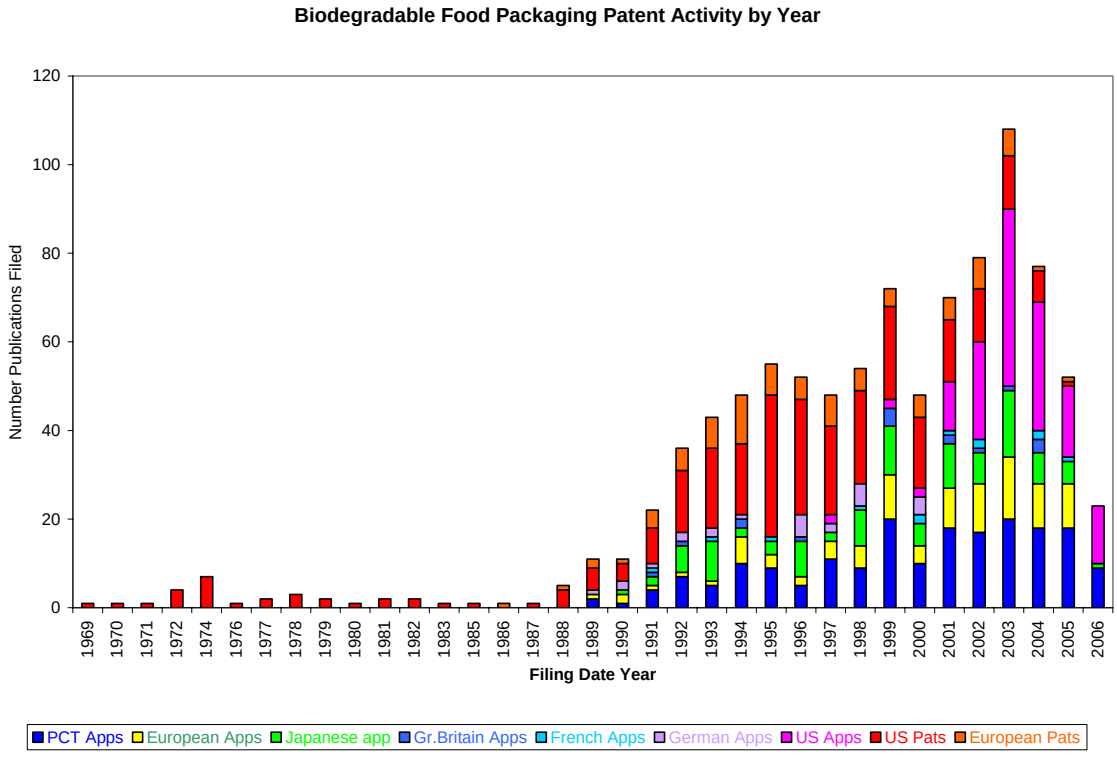

Figure 1 above compares the U.S. biodegradable food packaging patent activity (red for granted patents, pink for applications) with the Japanese (lime green) and European (all the others), and indicates a growing interest in this technology

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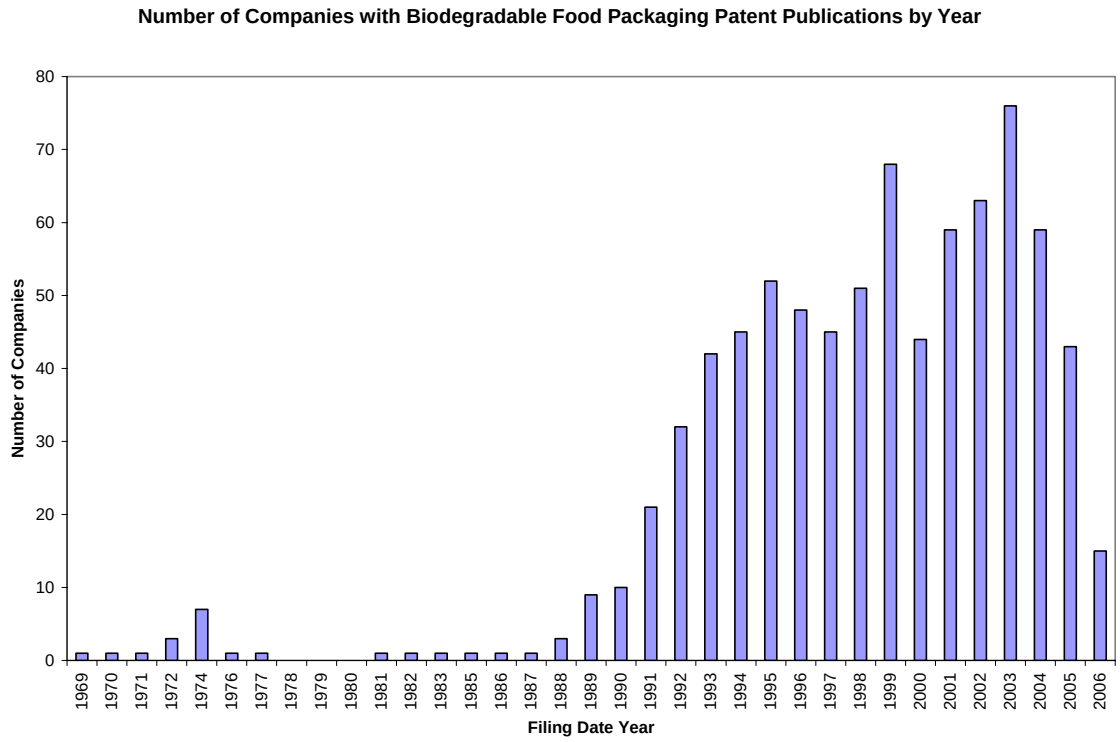
Figure 2 below further illustrates this trend, showing that the number of companies applying for patents increased through the 1990s and appears to have peaked in 2003. According to a product life cycle analysis in Rapra Technology's "Biodegradable Polymers" report, it takes about 30 years for a product to move through the research and development stage to become a commodity product with production measured in millions of tons. By that standard, and as evidenced by patent activity, the bioplastics market has been developing for over 20 years and is now reaching the market introduction stage. Further product and process developments are likely to lead to a continuing growth spurt in commercialization well into the next several decades.

Figure 2



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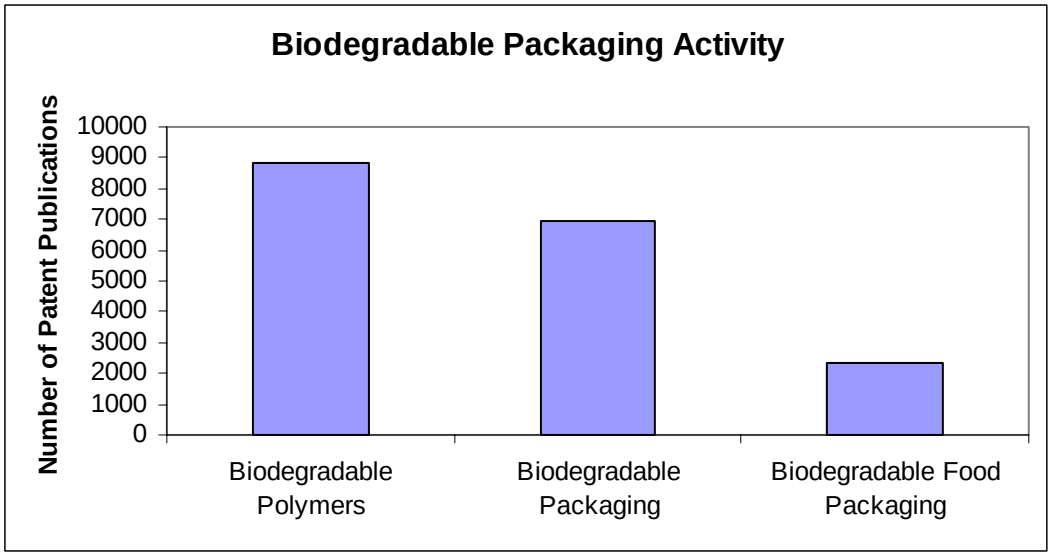
PATENT OVERVIEW

A search of Nerac patent resources (see Appendix 1) for publications concerning biodegradable polymers yields 8,843 results. When the topic is narrowed to biodegradable packaging, the number of patent publications is reduced to 6,972. Further focusing on biodegradable food packaging results in 2,320 patents and patent applications. Figure 3 below shows the relative proportion of each category. Currently, packaging accounts for 39 percent of the overall biodegradable polymer market, with food packaging only a small fraction of that.

Figure 3



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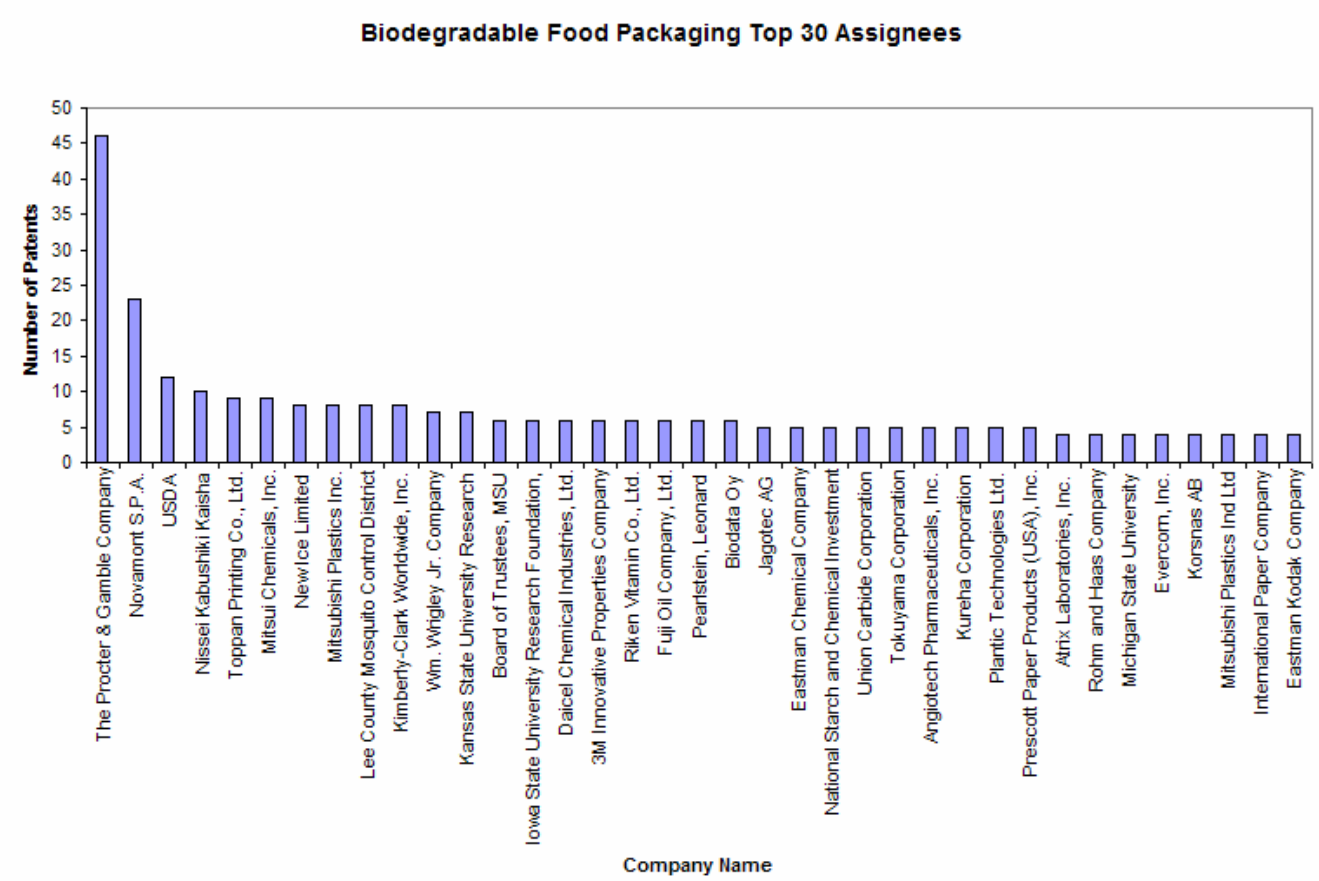
Sorting the biodegradable food packaging patent publications by company shows 440 different company names listed as the first assignee. The U.S. does not require that a company name be associated with an application. Identifying the top 30 companies listed as first assignee indicates which companies are most active in patenting new technologies and processes, as shown in Figure 4.

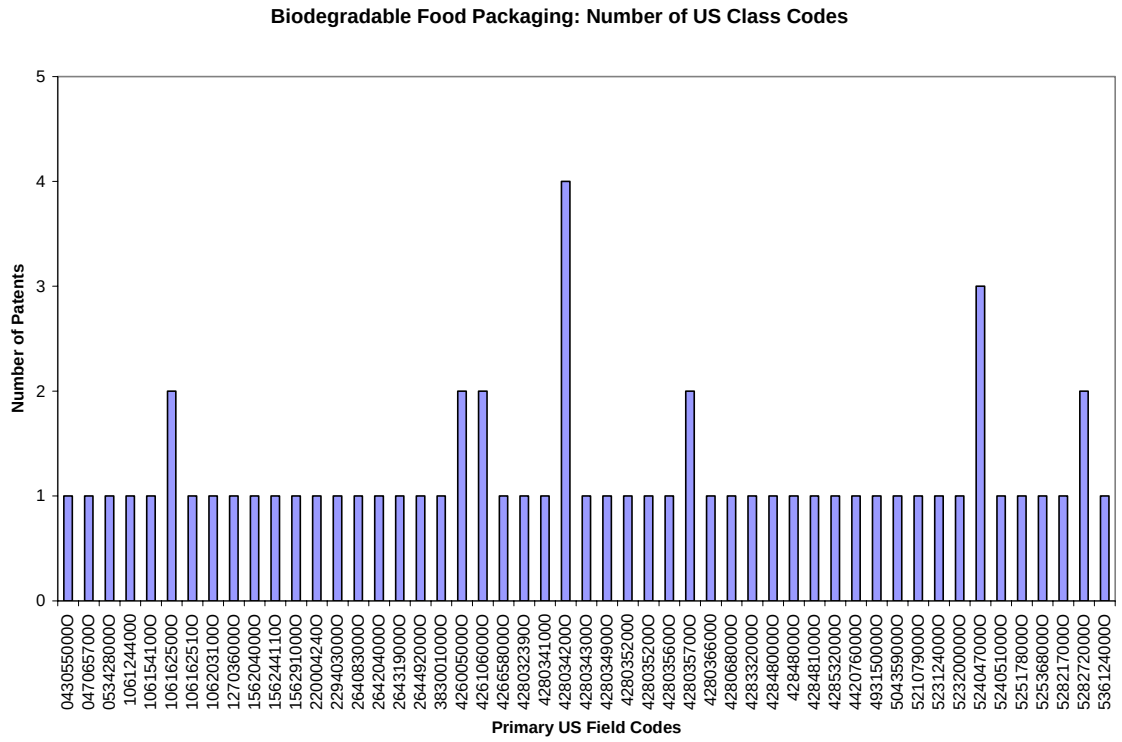
Figure 4



According to the Rapra report, 30 suppliers are currently active in the global biopolymer market, with BASF, DuPont and Mitsubishi Gas Chemicals dominating. Novamont, NatureWorks, Rodenburg Biopolymers and Biotec, established primarily to develop bioplastics, lead the starch and PLA segments, with the first three of those accounting for 90 percent of the European market. Novamont and Mitsubishi are also found among the patent leaders, suggesting that competition could heat up over the next few years.

Patents are classified into groups using numbered codes based on the type of invention. An analysis of these patent class codes can often be useful. Figure 5 shows the primary U.S. class codes for the 194 results of a tightly focused biodegradable food packaging search. The 61 results that had a primary U.S. class code were distributed among 55 different classes and subclasses. A similar analysis of the international class codes showed 163 patents with primary international class codes distributed over 93 classes and subclasses. The large number of class codes illustrates the breadth of this topic. Some inventors approach this as the development of a new polymer film, others as a food wrapper or container, while still other inventions are a process for increasing a polymer's susceptibility to hydrolysis, or improving some other property, such as stability to UV radiation.

Figure 5



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Patents using 11 different starches as source materials to create polylactic acid (PLA) bioplastics were reviewed for the five-year period of 2002-2006 (See Figure 6). Contour Semiconductor, CS Environmental Technologies, and G5 Manufacturing Ltd. were found to dominate the patent activity in this narrowly focused arena. The following patent publications showcase the technologies and activities of the companies in this field:

Contour Semiconductor, Inc. a U.S.-based company, disclosed a technology using corn starch, potato starch, and cassava starch as a biodegradable composition for the preparation of table-ware, mulching film, and packaging in patent application 20060199881/US-A1.

A European company, CS Environmental Technology Limited, in patent application 1176174/EP-A1, disclosed the use of potato skin, wheat, corn, peanut, and coconut as degradable raw materials for containers and packaging.

Biotec (GMBH) a German subsidiary of Great Britain's Stanelco, filed U.S. patent application 20030187149/US-A1 for a biodegradable polymer blend using potato.

Eco-Well Co. Ltd., another European company, focuses on using rice husks in biodegradable foam in its patent application, 01702946/EP-A1.

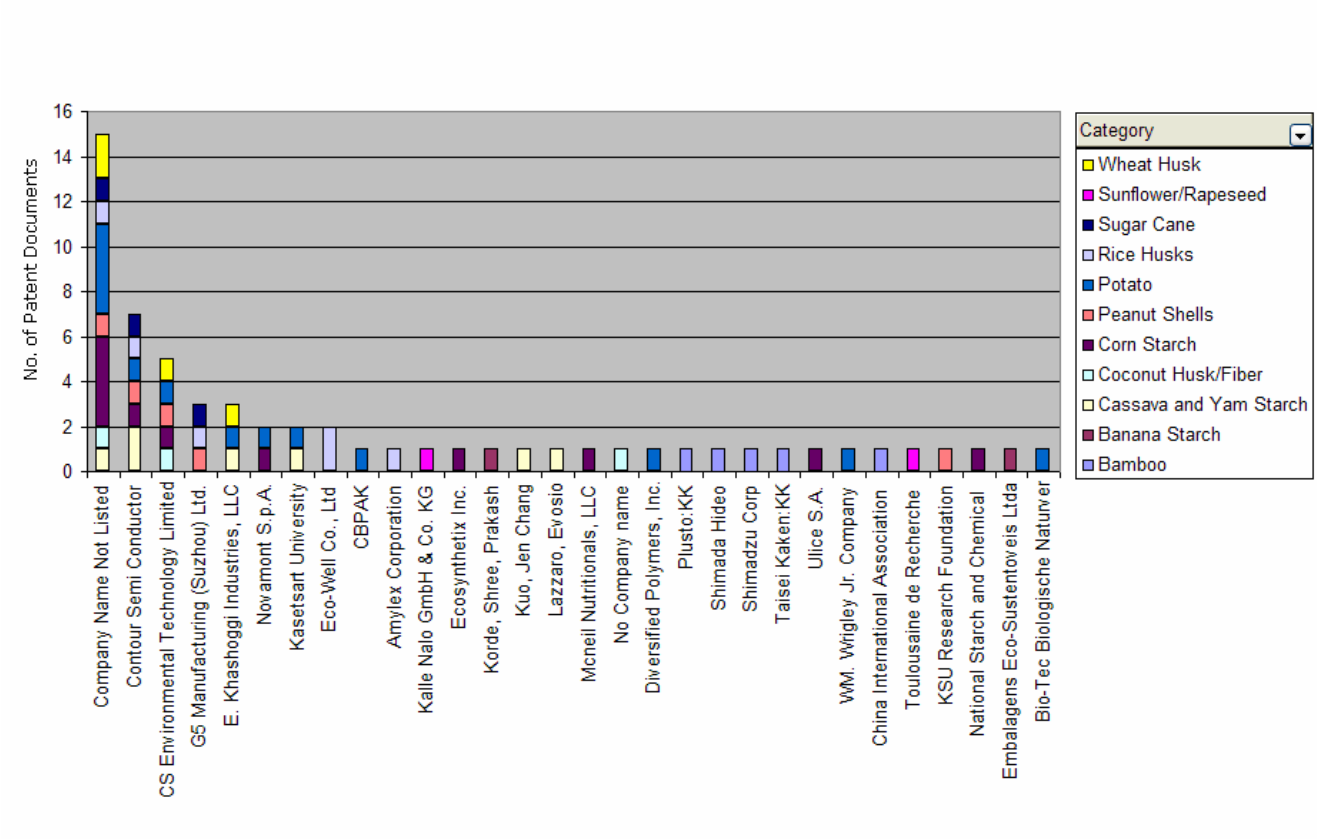
Novamont S.p.A is among the key players in the world producing biodegradable foamed plastic material using complexed thermoplastic starch from corn and potato in European patent 01038908/EP-B1.

Biodegradable expanded corn starch products as a loose-fill packaging material are disclosed in patent 00965609/EP-B1 by National Starch and Chemical Investment Holding Corporation.

Plusto:KK invented biodegradable resin foam sheet for packaging fruits or the like using bamboo-trunk fiber disclosed in Japanese patent 02322307JP.

A number of other companies, such as Dupont, EarthShell, NatureWorks, Eco-pack, and Innovia Films, currently manufacture biodegradable food packaging but are not included in this intellectual property review. They may not have patents or patent applications to protect their trade secrets, their published patents did not fall into the 2002-2007 timeframe of this patent review, or their patent publications did not meet this very focused search criteria. This review includes a category, "Company Name Not Listed," which could reflect an inventor's desire to obtain patent protection for products without publicly linking the underlying technology to the product lines or applications.

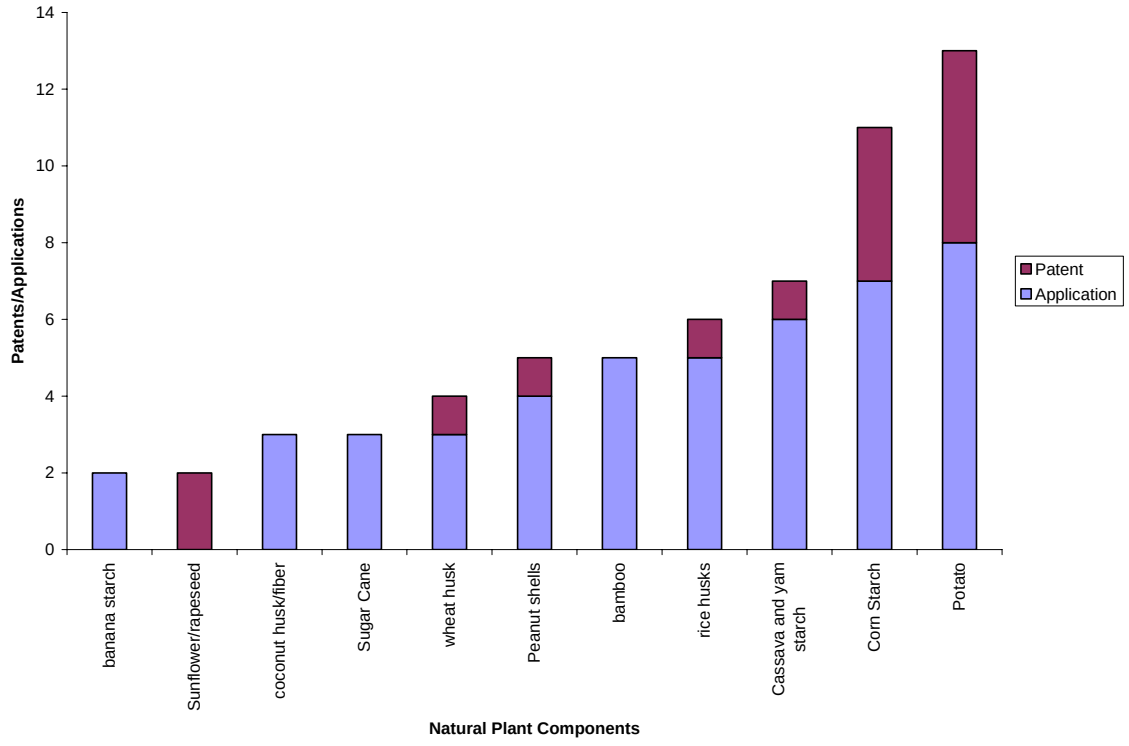
Figure 6



Competitor Patent Holdings by Natural Plant Components from 2002-2007.

Figure 7 shows that the most abundantly used natural material in biodegradable food packaging is potato, followed by corn. This is seen both in granted patents and patent applications. The greater number of patent applications as compared to granted patents during this time period of 2002-2007 indicates that it is an emerging technology. Also of interest is that the use of sugar cane, bamboo, coconut husk and banana starch are in patent application stages; whereas, the use of sunflower/rapeseed in biodegradable food packaging have already been patented.

Figure 7



Patent activity of Natural Plant Components used in Biodegradable Food Packaging 2002-2007.

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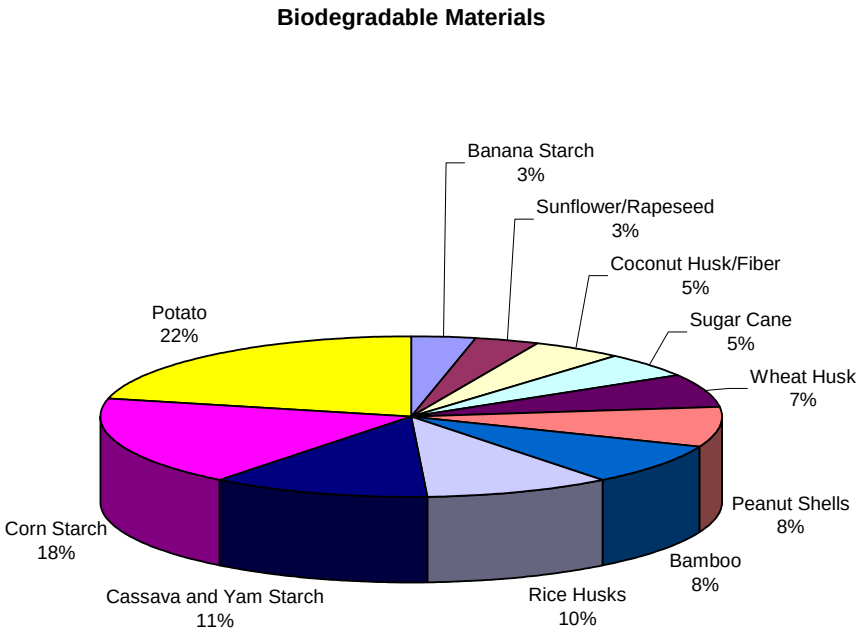
Figure 8 expresses the number of patent publications using a specific natural plant material as a percentage of the patents using 11 different natural plant components in biodegradable packaging. Potato starch has the largest share, followed by corn starch then cassava starch, probably due to their worldwide availability. Bamboo is used only in Japan. Increased use of natural plant materials such as corn to produce ethanol has caused the packaging industry to use other raw materials such as peanut shells, rice husks, wheat husks and coconut husks, which are primarily waste materials and thus less expensive to use. Sugar cane accounts for only 5 percent of the patent activity, which could be due to its lack of availability and other uses.

Figure 8



Percentage of Patents Incorporating Specific Natural Plant Components, 2002-2007.

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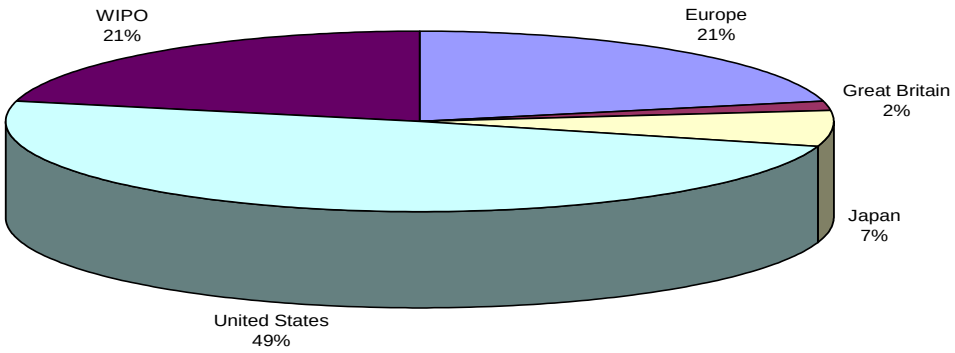
Figure 9 shows that nearly half of the filings examined were published in the United States (USPTO). The other half is divided among World patents (WIPO), European patents, Japanese and British patents. Many European companies are filing their patents in the United States to get more market share. For example, UK-based Bio-Tech has a U.S. patent application, 20030187149/US-A1, for a biodegradable polymer blend using potato starch. Currently, Europe, with its limited landfill space and tougher recycling regulations, accounts for 59 percent of the world's consumption of biodegradable polymers, with the U.S. consuming 22 percent and Asia 19 percent. Based on recent increases in U.S. patent activity, however, a shift in the North American market seems likely, as packagers, driven by consumer demand, shift to more environmentally friendly technologies.

Figure 9



Geographical Distribution of Patent Activity for Use of Specific Natural Plant Components.

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ANALYST INSIGHT

Oil prices are unlikely to decline, which creates opportunities for packaging materials manufactured from other sources, especially natural plant materials, to become competitive. Consumer demand, compounded by the proliferation of convenience foods requiring more packaging, forecasts that there will be continuing desire by companies to explore additional technologies deemed friendlier to the environment.

Advances in technology continue to expand the applications for biopolymers in food packaging and additional research continues, which leads to the conclusion that this nascent market segment will continue to grow, as better materials are developed and additional manufacturers bring more capacity on line.

Currently, only NatureWorks, Novamont, Rodenburg Polymers, and BASF have substantial production capacity, according to Rapra's "Biodegradable Polymers Market Report." However, about 30 companies are reported to be investigating or developing bioplastics. The timeline of product development indicates that it takes about 30 years for a product to move through research and development into production before manufacturing capacity reaches economic viability. The past decade or so has largely been devoted to research and development, and manufacturing capacity still lags. However, as more capacity is generated, the economic balance will shift in favor of renewable materials over dwindling supplies of petrochemicals.

Packaging companies have recently introduced biodegradable plastics made from a variety of natural plant materials, including potato, corn, cassava and others. There is growing interest in this technology, due to improved functionality of the bio-based packaging plastics and growing market demand. These biodegradable packages are formulated from naturally abundant agricultural residues, which have the advantage of using sustainable plant components that can be economically converted to useful products.

The most important hurdle to overcome is market development. Food manufacturers need to understand that encasing products in environmentally friendly packaging can be a significant selling point. Additional applications must be developed to improve bioplastics' versatility, and composting capabilities must be expanded to fully exploit the biogradability of these products.

Finally, there is the moral consideration of diverting crops to something other than food. Notes Lester Brown, president of the Earth Policy Institute: "Already we're converting 12 percent of the U.S. grain harvest to ethanol. How much corn do we want to convert to nonfood products?" The USDA estimates that percentage could double by 2014, which raises the question of whether corn in particular can remain economically viable, if demand forces up prices. Add the vagaries of nature—drought, for example—and the economics could be altered significantly.

Another prominent trend in food packaging is the development of intelligent packaging and these two technologies are being combined in such products as the biodegradable resin foam sheet for packaging fruits and other perishables, using bamboo-trunk fiber with a natural anti-bacterial agent applied on the surface, as shown in Japanese patent 02322307JP. There will be many more advances in biodegradable food packaging, as other new technologies are developed.

PATENT METHODOLOGY & SEARCH STRATEGY DISCUSSION

For any patent search, not only is the selection of keywords crucial, but where the search strategy requires them to be is equally important. A dataset is compiled by iterative searching of national and world patent libraries using key terms and class codes. By reviewing search results, determinations are made to refine the search or to capture and cluster the results within categories or characterizations related to underlying technology. The resulting database is then formatted and analyzed to identify trends and present insights which could be of interest to the client.

The only way to be absolutely sure that all relevant publications are identified is to read everything. Obviously, there is a need to generate a manageable subset to review. The scope of the search can be focused either by adding additional keyword requirements or by focusing where the key words are sought. If the search is limited to patent titles, for example, it is likely that any patent that fulfills all of the key word requirements in the title will be relevant. Although the relevancy rate of the results will be high, so will the number of relevant publications that will be missed. As the scope of the search is broadened, the likelihood of missing relevant publications decreases, but the proportion of irrelevant results increases. Thus, one of a Nerac analyst's main goals is to determine the balance between comprehensiveness and relevancy that would best suit a client's needs.

In this sample report, the biodegradable polymer data set was generated by searching for a biodegradable term and a polymer term in patent titles only, which yielded 4,172 results. Expanding the search to allow the term to be in the abstracts and exemplary claims brought the number of results to 8,843. Adding a requirement for a packaging term in the title, abstract or any claim, decreases the number of results to 2,729. If the terms are allowed to be in full claims or full text of the patent 6,972 results are found. When the search is further focused by adding a food term requirement, 946 patent publications are produced. This is the data set from which the number of companies and number of patents by year graphs were generated. Allowing the food term to be in full claims and full text increased the results to 2,320. Requiring the biodegradable term be in the title narrowed the search to 194 results, a more manageable set of patents for analysis. This is the data set used for the top companies and class code graphs.

For the narrower patent analysis of the use of natural plant components as raw materials used in biodegradable packaging, patent listings were imported into Microsoft Excel using Nerac's proprietary analytical programming. This dataset consists of published patent references from 2002-2007 from searches for biodegradable packaging and each of 11 natural plant components.

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APPENDIX 1: PATENT RESOURCES

US Patent Full Text Applications	2001 – Present
European Full Text Applications	1978 – Present
European Full Text Granted Patents	1978 – Present
France Full Text Patent Applications	1980 – Present
Great Britain Full Text Applications	1918 – Present
Germany Full Text Patent Applications	1980 – Present
Unexamined Japanese Patent Application Abstracts	1995 – Present
World Full Text Patent Applications	2004 – Present
US Granted Full Text Patents	1836 – Present

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APPENDIX 2: KEY WORDS SEARCHED

Biodegradable Terms:
biodegradable; bio degradable; biodegradeable; bio degradeable; compostable; compostible; bio plastic; bioplastic; bio polymer; biopolymer; bio based polymer; biobased polymer; bio based plastic; biobased plastic

Packaging Terms:
packaging; package; film; bag; container

Food Terms:
food; beverage; comestible

Plant Component Terms:
banana starch; bamboo; cassava and yam; coconut husk; corn starch; peanut shells; potato; sugar cane; sunflower and rapeseed; rice husk; wheat husk

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ABOUT THE ANALYSTS

SHAHANA JAHANGIR

Shahana Jahangir works with food and beverage companies to assess new and existing technologies to create new products and improve existing products. Her insights and analysis help companies gather timely business and marketing data to evaluate market position. Before joining Nerac, Ms. Jahangir worked on UHT milk processing, fruit juices, infant formulas, and baby cereal technology at Nestlé, and soft-drink quality control at Coca Cola. Her areas of expertise also include dairy technology, palm oil processing, super-critical fluid extraction, and ELISA-based methods used in dry milk. Born and raised in Pakistan, Ms. Jahangir has traveled extensively through Africa, Asia, the Middle East, and Europe, and her academic and professional background is similarly culturally and geographically diverse. After earning a bachelor's degree in food processing technology at Federal University of Technology in Nigeria, she was awarded a Scholarship by the United States Agency for International Development (USAID) and earned a master's in food science at Virginia Tech. She is a member of the Institute of Food Technologists.

MARY JO LEBER

Project Analyst Mary Jo Leber works with a wide range of companies, tracking the most recent developments and assisting with interdisciplinary research and analysis in subjects ranging from food science and packaging to concrete chemistry and nanotubes. Dr. Leber worked for over eight years in agricultural formulation development with North Carolina-based Ciba-Geigy/Novartis and has taught chemistry and astronomy at various colleges and universities. Her experience in developing and testing powdered, granulated, suspension and emulsified formulations translates to other industries, particularly food science R&D. She holds Ph.D. and master's degrees in physical chemistry from Rice University and a bachelor's in biology from Texas A&M. Her undergraduate research, primarily as a double botany/zoology major, led to an interest in pharmacognosy and nutraceuticals. Her graduate work in physical chemistry involved the photochemistry and photophysics of small clusters of atoms in molecular beams and led to her interest in vapor deposition technology, the science of various materials and nanotechnology, in general. Dr. Leber is also a USPTO-registered patent agent.

ABOUT NERAC

Nerac is a Research and Advisory Firm for companies developing innovative products and technologies. Nerac provides clients access to Analysts who serve as advisors and deliver custom assessments of product and technology development opportunities, competitive threats, Intellectual Property strategies, compliance requirements, and scientific review and problem-solving. Nerac serves as a catalyst for new thinking in your organization and strives to inspire teams to creatively approach business problems and identify strategic growth opportunities. Nerac deploys analysts in diverse disciplines allowing you to apply expertise from outside your niche to discover new applications that may not be apparent otherwise. Clients benefit from our proven blended approach to custom analysis: review of technical knowledge, investigation of intellectual property, and appraisal of business impacts. Nerac Analysts are empowered with vast research and marketing information as well as a worldwide network of thought-leaders and innovators. Nerac clients attest to our commitment to provide them the best service in the industry — nearly 90% of them renew their partnerships with us every year.

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