

# Opportunities and challenges of the Biotechnology sector in Apulia

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## Introduction

Biotechnology is living a period of continuous and rapid changes with both immediate and potential advantages for businesses and policy makers (Zika *et al.*, 2007).

There are various definitions of the science known as biotechnology. The European Federation of Biotechnology gives the following definition "the integration of natural sciences and engineering sciences in order to achieve the application of organisms, cells, parts thereof, and molecular analogues for products and services" (Commission of the European Communities, 2007). According to another defini-

tion put forward by the OECD, biotechnology is "the application of science and technology to living organisms, as well as parts, products and models thereof to alter living and non-living materials for the production of knowledge, commodities and services". This covers an extremely wide range of activities ranging from very simple traditional processes like those used in the production of beer, wine and cheese, to highly sophisticated and complex molecular processes, like the use of recombinant DNA in the manufacturing of medicine or the introduction of new qualities to vegetables and animals of commercial value (Buratti, 2001).

This paper aims at evaluating the opportunities of development of the Apulia production system in the field of biotechnology. By studying both the industrial characteristics and the peculiarities of Apulia, it was possible to identify and classify the different biotech applications that can stimulate an eco-

## Abstract

Biotechnology offers new opportunities to meet many needs of economic growth, public health and environmental protection. This can represent an immediate and potential advantage for businesses and policy makers. In this article, national, European and international markets will be evaluated on the basis of their economic, social and environmental aspects in order to highlight the Biotechnology features that have been set up over the last few years and understand its possible future applications. Opportunities for its development at a more local level, the regional one, will be taken into account.

**Key words:** Biotechnology, agrifood industry, innovation, territorial development.

## Résumé

*Les biotechnologies offrent des nouvelles possibilités pour satisfaire les besoins concernant la croissance économique, la santé publique et la protection environnementale. Ceci pourrait représenter un avantage immédiat et potentiel pour les entreprises et les décideurs politiques. Cet article fait une évaluation des marchés nationaux, Européens et internationaux sur la base d'aspects économiques, sociaux et environnementaux analysés pour mettre en exergue quelles sont les biotechnologies déjà mises sur pied ces dernières années et comprendre quelles sont les possibles applications futures dans le secteur des biotechnologies de surcroît, les chances de développement des biotechnologies au niveau régional seront prises en compte.*

**Mots clés:** Biotechnologies, système agro-alimentaire, innovation, développement territorial.

conomic growth in a region that, in 2006, was characterized by the highest number of biotech companies in the Southern Italy after the Campania region.

In the first part of the study, after exploring the main sectors of application of biotechnology at different national, European and international levels, literatures were reviewed.

In the second part, the industrial system of the region was analysed from a technical and economic point of view in order to identify the main sectors which a potential short and medium run development.

Eventually, two criteria were identified to evaluate the plausible biotech applications in the Apulia

industrial sector. They are: a) process or product innovation in the food industry and/or use of the agri-food by-products, and b) innovations in energy chain systems.

## Areas of Application of Biotechnology

Even if the technology used is of different type, there are basically three broad areas of biotech application: environment and energy, crop production and agriculture, and health care. Recently, however, the application of nanotechnology is opening new perspectives with organic microchips and biosensors.

Different types of technology are used to protect and/or preserve the environment. For instance, biotechnology can protect the environment, through systems for wastewater treatment, for removal of nitrates from water, for reclamation of contaminated land (Smith, 2002).

As far as the energy sector is concerned, biotechnology is used in the production of biofuels, such as bio-ethanol and organic hydrogen. The first product is largely based upon biotech-

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nology, with the use of enzymes or micro-organisms to produce ethanol from plant residues, wood or biodegradable waste.

In the complicated agri-food sector, biotechnology is used in a myriad of different ways.

A constantly increasing number of genetic engineering experiments are carried out in the agricultural sector for plant protection and production increase purposes. Attempts are also made to improve the agricultural products characteristics by increasing the quantity and quality of nutritional values, enhancing resistance to environmental stress factors (drought, salinity, low temperatures, etc.), parasites and other pathogens.

The creation of transgenic self-fertilizing plants is the cutting edge of this sector, by inserting bacterial genes involved in nitrogen-fixing activities. The use of biotechnology in the production of foodstuff is well established today, for example in all fermentation processes using different types of micro-organisms, like yeasts (Poli, 2001).

In general, in this sector, biotechnology is used in order to 1) improve the quantity and quality of plant (cereals, vegetables, fruits) and animal products (milk, meat, eggs) together with transgenic plants and animals, and 2) improve the use, processing and preservation of raw materials and food derivatives.

As far as the health care sector is concerned, modern biotechnology is applied in four ways. First, biotechnology targets on making production methods more efficient, as in the increased production of pharmaceuticals such as insulin, a growth hormone for pituitary dwarfism, vaccinations, plasma derivatives and many others. Second, it concerns research on molecular mechanisms that are the cause of certain diseases and the synthesis of molecules active in curing the diseases. For example, some monoclonal antibodies are used to fight against leukaemia and cancer, and interferon is administered to control multiple sclerosis and other diseases (Farminindustria, 2004). The third use in the health care sector is concerns diagnostic testing. DNA micro-sequences are used to diagnose serious diseases such as tuberculosis, AIDS and others. The fourth application of biotechnology is in gene therapy, based on the use of stem cells for therapeutic purposes. This very last application is currently hampered by bioethical dilemmas.

From a scientific, industrial and commercial point of view, it is possible to distinguish between classic, traditionally known as mature, biotechnology applications such as fermentation in foodstuff production or exploiting of agricultural surpluses or waste to produce biomass, and innovative or radically new applications that represent an improvement in the existing practices (Buratti, 2001).

## Economic Features

From an economic perspective there are few biotechnology companies currently operating in the world, just over 5,000, with revenue of almost 69,000 million dollars in 2006. Looking at international data, there is a high concentration of businesses settled down in Europe and in the United States (2,000 each), followed by Asia-Pacific with 700

companies, and Canada with nearly 460. There are however striking differences between the US revenue and the European one (42,000 and 21,500 million dollars respectively), as pointed out in Table 1. Investment in research and development is also notably higher in the United States, exactly alike the number of employees, which is about twice the investment in Europe. Biotechnology patents registered in 2002–2004 were 2,576 in Europe, 3,331 in the United States and 1,035 in Japan. At a European level, Germany ranked first with 901 patents submitted to the EPO (European Patent Office) followed by the United Kingdom with 416, France 370 and Italy with 124 (Felix, 2007).

Table 1 – *Worldwide Biotechnological Companies in the in 2005/2006.*

Company data	Global	U.S	Europe	Canada	Asia-Pacific
Revenues (million of dollars)	69,000	42,000	21,500	2,600	3,000
R&D expenses (million of dollars)	20,400	16,000	3,300	852	312
Number of companies	5,175	2,000	2,000	459	716
Number of employees	304,400	190,000	90,000	11,900	12,500

Source: authors' data elaboration (Szaro, 2007; Munn-Venn, 2005; Ernst & Young, 2006; European association for Bioindustries, 2007).

Amongst the European countries, the current leader in the biotechnology industry is Germany, with 538 businesses, followed by the United Kingdom with 457 and France with 233: together they account for just over 50% of the total.

With 228 businesses (roughly 11% of the European total), in 2007, Italy consolidated the good trend of previous years (Blossom Associati Management Consulting, 2008). It must be underlined that about 60% of these businesses were created in the last 10 years.

Businesses are mainly small (about 75%), but there are also large (13%) and medium-sized ones (12%). The Italian biotech sector is characterized by geographical concentration as follows: about 34% in Lombardy while, the other Italian areas of interest include Piedmont, Lazio, Tuscany, Emilia Romagna and Sardinia; Apulia has 1.99% of the total number of companies. As far as areas of work are concerned, 40% of companies work in the health care sector, 16% in chemistry and environment, 14% in agri-foods, and 30% in diagnostics, engineering and others.

It is important to underline that the statistics regarding this sector, such as the data outlined above, only regard "biotechnology businesses", or rather those exclusively dedicated to this business, thus excluding numerous businesses that make use of biotechnology for both manufacturing new products and improving production methods.

## Strategies for biotechnology

Recently, the growth rate of new biotechnology firms in Italy offers grounds for hope and will perhaps enable us to catch-up with the rest of Europe and the United States. There is discussion about opportunities for growth, innovation and competition in the Italian biotechnology industry.



Specifically, there is discussion regarding the need to find new investors that will take a chance on the possibility of growth in this sector. Notwithstanding the progress made by this country, there remain difficulties in obtaining adequate resources. The sector is financed by rather limited public funding with insufficient risk capital for biotech.

The basic problem therefore remains the lack of public incentives and venture capital that would stimulate the market through the birth and start-up of new firms. Nonetheless, it has to be emphasised that new biotech firms do not only need capital, but also consultancy services and management experience. It is therefore necessary that the investors of risk capital do not only support the new businesses by providing capital, but also by managing the know-how. Through contact and collaboration with other businesses in the same or different sectors, in collaboration with universities and private research centres, the businesses will have the chance to grow (Reiss and Woerner, 2002).

The international scene highlights scientific and technical competence along with good working relations between the various disciplines involved in biotechnology, such as the foundations for progress in the biotechnology industry at the territorial level: university centres, research companies, venture capitalists and business have to co-operate to breathe life into the network (Costa *et al.*, 2004).

Biotechnology represents a strategic choice that promotes development in the national and European context since it is rich in innovation and is interdisciplinary, it can be adapted to regional settings, such as the improvement of local production systems. This developmental strategy has been put into practice by one regional government in the South of Italy, Apulia.

Apulia covers over 19,357.90 km<sup>2</sup> (about 6.4% of the national surface)<sup>1</sup>. In 2005, the total GDP for the region was around 65 billion euros (5% of the national GDP), which is 5% for agriculture and 10% for manufacturing industries (Osservatorio Regionale Banche Imprese di Economia e Finanza, 2005).

The importance of agriculture for the region can be seen in the high percentage of agricultural businesses (27%) with respect to the total number of active firms, which in 2005 were 384,000. The manufacturing industry *sensu stricto* covers 11% share and includes relatively small businesses, with employees numbering on average 3, a little higher than the regional average of 1.8 employees. Even if occasional employees are also included, 90% of Apulian businesses have no more than 5 employees (Istituto Pugliese di Ricerche Economiche Sociali, 2007).

The small to medium sized business sector indeed represents a large percentage of firms. This is encouraging them to obtain larger market shares, by increasing the contribution that they can make in terms of innovation, flexibility and the opening up of foreign markets. Without strategic in-

terventions the SMEs (small to medium size enterprises) might miss out in terms of getting the best deals and industrial restructuring.

Because of this, it is necessary to accelerate the movement towards obtaining new and more efficient competitive edges reinforcing the tendency to be innovative. Unfortunately, Apulian firms have not adequately benefited from research, development and technology transfer; there is also a weakness in terms of protecting results of innovation (for example through patents). It is necessary to enhance communication through the enlargement of the regional Research Plan and readiness to answer with specific initiatives in response to supply and demand, enabling co-operation between companies and the regional system of research and innovation.

### Potential biotechnology application at Territorial Level

The biotechnology applications to be developed in Apulia ought to reflect regional characteristics and according to the two main criteria above selected, a) innovation of process and/or product in food industry and use of the agro-food by-products, b) innovation in the energy chain, different examples of possible applications have been reported. Furthermore, the identification of these criteria allowed individuating, among the wide biotech applications above mentioned, the most suitable ones avoiding the loss of economic resources.

Innovation represents one of the main strategic factors of business success. It involves extensive research and consultation during the various stages of development, of both the product and the process, and requires resources and technical knowledge that are not always available in-house. In Apulia, nowadays, process innovation prevails (25-30% vs 20% in Italy), whereas the product innovation is underused (roughly 10% vs 18% in Italy). For this reason a strategic alliance between businesses and Universities or Centres of Research would favour the knowledge transfer for faster solutions.

Considering the characteristics of the agro industry in Apulia, different example of innovations that are going to be realized have been selected. The dairy industry is an important patrimony for the regional economy due to the typicality of the different kinds of cheese. The dairy operators are continuously searching for technology both for implementing and guaranteeing a constant quality of their products. In order to meet these needs, the isolation, directly from cheese or milk, of naturally pro-biotic micro-organisms is under investigation. This innovation should both enhance the overall quality of milk and preserve it from the bacterial degradation. Another important technological innovation would consist in the recovery by ultra-filtration of serum proteins from dairy products to obtain new products enriched with those proteins. What is more, in order to increase the yield of dairy products, at least 2-3 grams

<sup>1</sup> In Apulia the total agricultural area is around 71% of the entire one (1,379,277 ha) and the Utilized Agricultural Area (UAA) is 1,249,645 ha.



per litre of serum proteins should be added. In this way it would be obtained an extra production of 2-3 kg per day, without any additional cost.

Another possible application as the substitution of the rennin enzyme with a recombinated version is making progress, and engineered strains of bacteria are being experimented to start the casein-making.

The wine making sector in Apulia is facing some important changes from the qualitative point of view.

An essential requirement for operators of the wine industry is to be able to steer and control the process of microbiological fermentation in order to produce wine with unique characteristics and safe. Therefore, the selection and use of new yeasts, obtained from wild yeasts, would help to improve organoleptic characteristics of the wine. The opportunity of using wild yeast replacing those currently available in the market will preserve the peculiar characteristics of the products in order to valorise the quality of the Apulia wine.

The olive sector is increasingly moving towards quality production. For instance, the Protected Designation of Origin (PDO) label certifies the use of specific disciplinary production keeping the typicality of the product. Modern application in the field of biotechnology for food products has to meet quality demands and provide some information on the different steps involved in the technical process. This means to meet the ever-pressing needs to identify parameters such as traceability, quality and food safety. For the product traceability, for example, biotechnological methods based on DNA analysis for the identification of molecular markers (microsatellite and AFLP) have been developed. In this way, it is possible to exactly identify the cultivars used in the production of some typical oils. Another application can be the development of new enzyme technology or new tests for checking contamination of foodstuffs. In fact, this application of biotechnology would allow the development of sensors and testing kits that provide precise and rapid information regarding the presence of pathogenic micro-organisms and contaminated substances in food at all stages of the production chain in order to evaluate the quality of foodstuffs.

Another potential field for the development of biotech innovation is the environmental protection. Every year, for example, the problem of waste disposal resurfaces in Apulia. This situation could be resolved and at the same time be a stimulus to new production initiatives, through the application of biotechnologies that provide the best solution to the problem. The traditional technology used for composting the organic fraction or the anaerobic decomposition of wastes should be improved by means of innovative applications. This is all very necessary considering that in Apulia, in line with the national trend, compost production, made from organic waste, has overall increased (around 180,000 t).

There are plenty of applications in the environmental sector, as biosensors for environmental monitoring, quality testing and pollutant removal from water supply (Grommen, 2002).

The innovation in the energy chain is also very strategic. There could also be various developments in biotechnology in the energy sector, for example in the production of ethanol, or other fuels, like methane or hydrogen, using different technologies always deriving from biomass, especially bearing in mind the high degree of land designated for agricultural use in the territory of Apulia (P.E.A.R., 2007).

Agricultural crop waste could represent a real opportunity, from the point of view of saving energy, and in terms of solving a waste disposal problem for farmers. In this region, there are various agricultural crops and their by-products that can be used for energy. Cereals are the most widespread crop (about 32%), followed by olive (25%), permanent grass crops (10.8%), grapes (10.6%), temporary grass crops (7.5%), vegetables (7%), fruit trees (3.7%), non-food crops (1.3%) and citrus (0.8%).

It is possible to estimate the quantity and quality of residues in Apulia as shown in Table 2.

Crop	Crop residue availability (t/y)	Crop residue availability (%)
Wheat	433,329	92.8
Barley	12,321	2.6
Oat	21,531	4.6
<b>Herbaceous crops</b>		
<b>Total</b>	<b>467,181</b>	<b>100</b>
Olive	172,318	34.4
Grape	298,569	59.6
Almond	29,905	6
<b>Arboreal crops</b>		
<b>Total</b>	<b>500,763</b>	<b>100</b>
<b>Forest residues</b>		
<b>Total</b>	<b>6,342</b>	
<b>TOTAL</b>	<b>974,286</b>	

Source: (Paiano et Al., 2008)

However, it is worth underlining that the high level of fragmentation in agri-food activity in the territory currently makes difficult the collection of such by-products or waste: high territorial dispersion, no efficient collection, transport and storage systems and high costs can be the obstacles to their widespread exploitation. Different localisation, for example, by concentrating crops that produce the same waste in the same area, would lead to optimal recycling.

The health care sector has infinite possibilities for biotechnology breakthrough. Notwithstanding this fact, should biotechnology be developed in a territory like Apulia, on the one hand elements of criticality may appear, while on the other hand positive consequences could include financial considerations. Criticalities might include the extremely high level of specialisation required to work in this sector, the lack of a pharmaceutical industries in the area and the relatively high costs compared to other forms of biotechnology.



## Conclusions

This study shows that in Apulia few biotech innovations could be applied. Without any doubt, the possible development of biotechnology in the territory of Apulia depends on the successful transfer of technological know-how from research centres or universities to local businesses, especially because of their small size. With this in mind, adequate professional training of personnel in these businesses becomes fundamental for them to be able to take full advantage of the possibilities for acquiring new processes and biotechnological products. The professional training could be a challenge for the Apulia production structure, since it is characterised by lots of small traditional businesses.

Financial support and risk capital should be made available for these small businesses, also from institutions. In the last few years, the regional government of Apulia has promoted several programs for encouraging the innovation technology within industry and research also by improving their relationship. For instance, a local Bio-pole involving the Universities of Bari, Foggia, Lecce and Research Centres in the biotech sector was created in order to facilitate the creation of Centres of Excellence, capable of generating the start up of new businesses, generally small spin-offs, and the settlements of medium and large enterprises. The expectation was to create an incubator of productivity through a network also linked with European research centres of highly specialized skills.

Furthermore, the network that will come into being could attract venture capital in Apulia, from national and foreign companies, as well. At the same time, greater openness and visibility are evident; perhaps, we will see the conquering of new markets, especially abroad. The international competitive system that continuously evolves does not allow the region to accumulate further delays in terms of development that could undermine the process of integration in the European context.

[§] This work is the result of the authors' commitment, starting from the idea and ending in its accomplishment. Particularly, the "Introduction and Areas of Application of Biotechnology" is ascribed to Giovanni Lagioia, the section "Economic Feature and Conclusion" is ascribed to Teodoro Gallucci, the sections "Strategies for Biotechnology" and "Potential biotechnology application at the Territorial Level" are ascribed to Annarita Paiano. In short, the contributions of the three authors are the same.

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