

ENZITEC 2016

XII SEMINÁRIO BRASILEIRO DE TECNOLOGIA ENZIMÁTICA

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Tecnologia enzimática no Brasil Necessidades e desafios

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Conteúdo

- Brasil situação atual
- Mercado atual de enzimas
- Produção científica - Patentes
- Fontes de biomassa e de resíduos agroindustriais
- Necessidades e Oportunidades

Brasil - Dados gerais

- 5º país mais populoso do mundo (1)
- Um dos países mais ricos em biodiversidade (2)
- 7ª economia do mundo em 2013 (3)
- 51 % das exportações brasileiras são “commodities”, ou seja, bens de baixa tecnologia (2010), correspondente a 5 % do comércio mundial (4)
- Apenas 0,5 da exportação são bens de alta tecnologia (4)

Daiha et al. Braz J Sci Technol (2016) 3:17

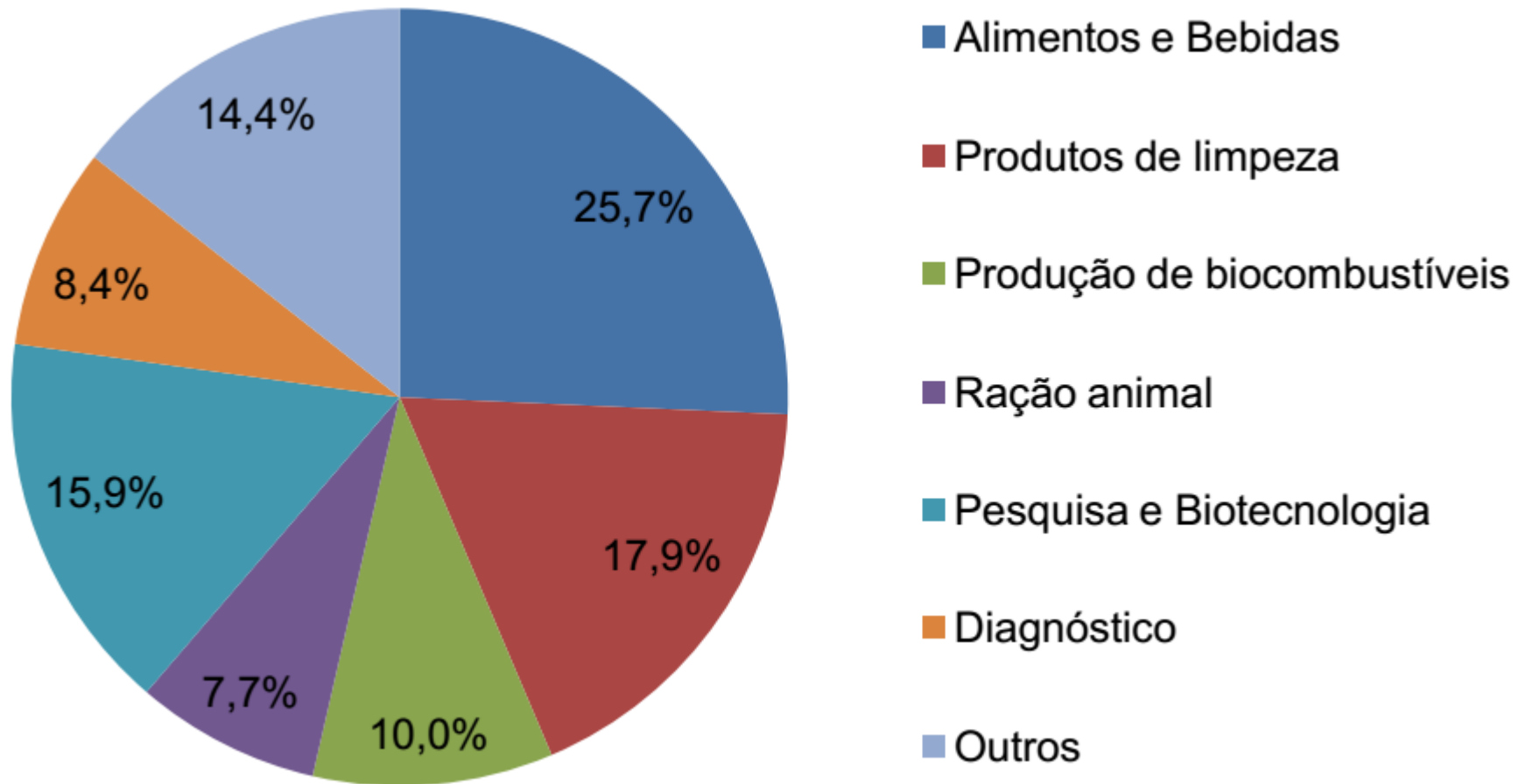
(1) United Nations Population Found, 2010

(2) Mittermeier et al., 2005

(3) Centre for Economics and Business Research, 2013

(4) Em discussão! Revista de Audiências Públicas do Senado Federal, 2012

Demanda mundial de enzimas por mercado



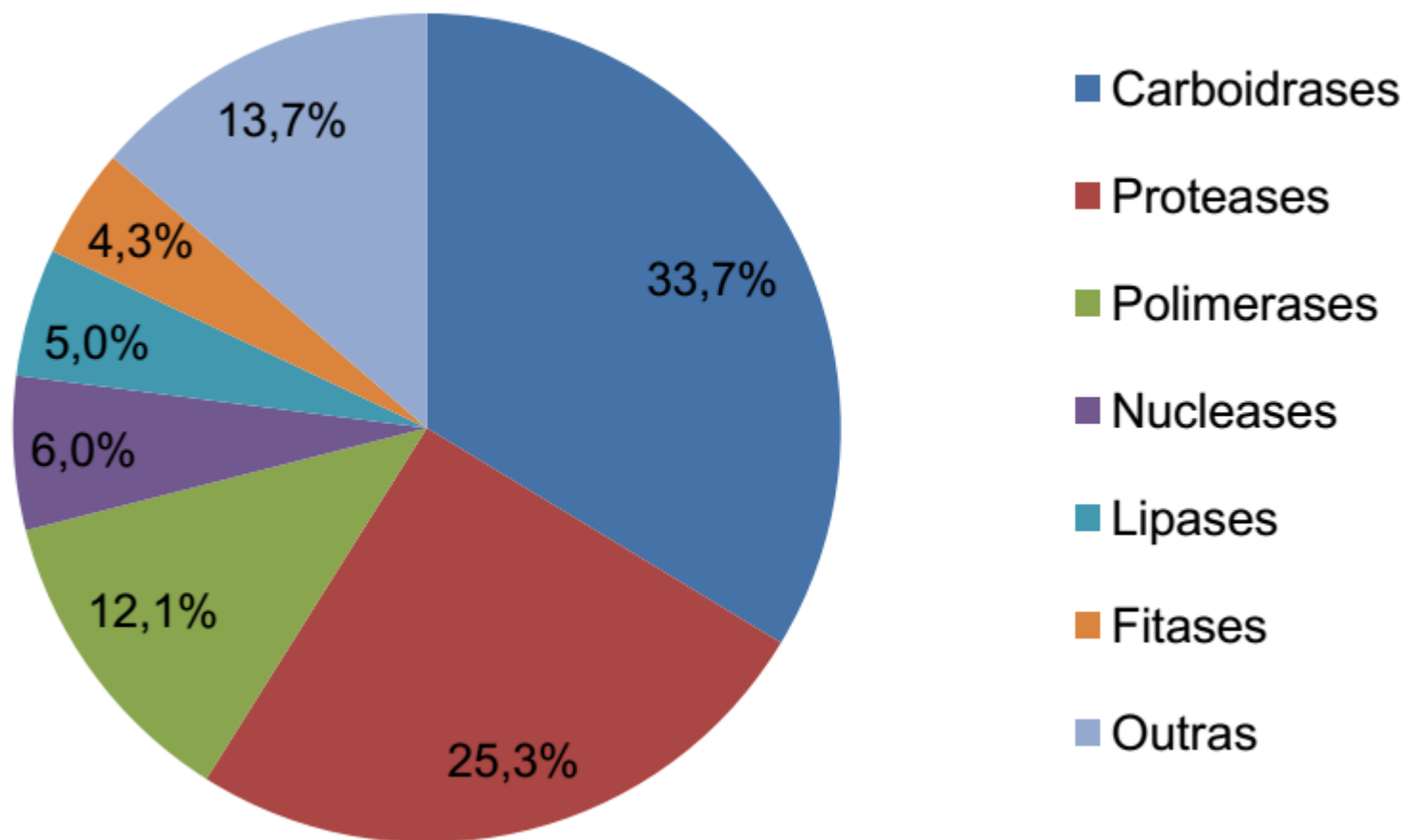
Fonte: adaptado de The Freedonia Group Inc., 2014

Mercados de enzimas industriais e especiais e suas respectivas demandas mundiais em 2012 e 2017

MERCADO	DEMANDA MUNDIAL (milhões de dólares)	
	2012	2017*
Enzimas Industriais:	3630	4760
Alimentos e Bebidas	1320	1865
Produtos de limpeza	920	1245
Produção de biocombustíveis	515	555
Ração animal	395	540
Outros	480	555
Enzimas Especiais:	1500	2190
Pesquisa e Biotecnologia	815	1180
Diagnóstico	430	640
Outros	255	370

*projeção. Fonte: adaptado de The Freedonia Group, Inc. 2014

Demanda mundial estimada para 2017 por grupo de enzimas



Fonte: adaptado de The Freedonia Group Inc., 2014

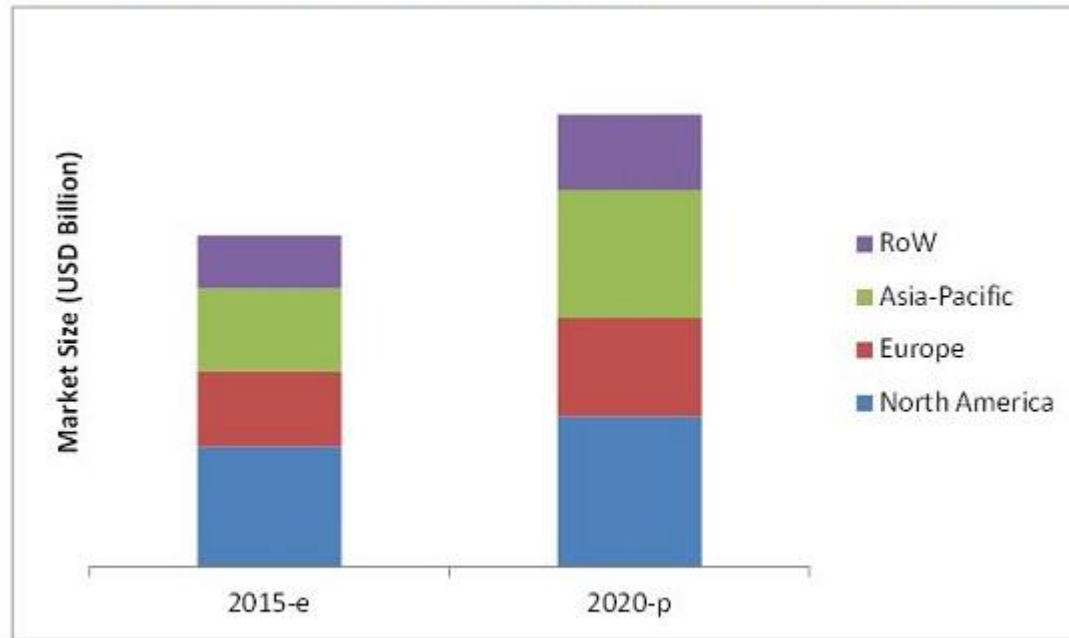
Enzimas mercado

- 75% das enzimas utilizadas industrialmente são hidrolases
- conhecidas, ao todo, em torno de 4000 enzimas
- apenas cerca de 20 são produzidas em verdadeira larga escala

(LI et al., 2012)

Industrial enzymes

Industrial Enzymes Market Size, by Region, 2015 vs. 2020 (USD Billion)



Source: MarketsandMarkets Analysis

E - Estimated, P - Projected

compound annual growth rate (CAGR)

The concept of CAGR is relatively straightforward and requires or investment's beginning value, ending value, and the time period.

$$CAGR = \left(\frac{\text{Ending Value}}{\text{Beginning Value}} \right)^{\left(\frac{1}{\# \text{ of years}} \right)} - 1$$

Industrial enzymes

- The industrial enzymes market was valued at **USD 4.2 Billion in 2014** and is projected to **grow at a Compound Annual Growth Rate (CAGR) of 7.0% from 2015 to 2020**. In 2014, the market was dominated by North America. The Asia-Pacific region is projected to grow at the highest CAGR from 2015 to 2020.
- **key players** in the market are BASF SE (Germany), E.I. du Pont de Nemours and Company (U.S.), Associated British Foods plc (U.K.), Koninklijke DSM N.V (The Netherlands), and Novozymes A/S (Germany) among others.
- The industrial enzymes market is segmented on the basis of type into **carbohydrases, proteases, non-starch polysaccharides, and others which include phytase, lipases, catalase, and tannase**. The carbohydrases segment is projected to grow at the highest CAGR of 7.5% from 2015 to 2020.
- On the basis of application, **the market is segmented into food & beverage, cleaning agents, animal feed, and others which include starch processing, textile & leather, biofuel**. The market for food & beverage projected to reach a value of USD 2.0 Billion by 2020.

Technical enzymes market

- The **technical enzymes market** is projected to **reach USD 1.27 Billion by 2021**, at a CAGR of **3.4%** from 2016 to 2021.
 - The technical enzymes market is segmented on the basis of type into **cellulases, amylases, proteases, lipases, and other enzymes**.
 - **segmented into bioethanol, paper & pulp, textile & leather, starch processing**, other applications
 - The **key players** involved in technical enzymes market include BASF SE (Germany), E.I. du Pont de Nemours and Company (U.S.), Associated British Foods Plc (U.K.), Koninklijke DSM N.V. (The Netherlands), and Novozymes A/S (Denmark). Other players include Dyadic International Inc. (U.S.), Advanced Enzyme Technologies Limited (India), MAPS Enzyme Limited (India), Epygen Labs FZ LLC (UAE), and Megazyme (Ireland).

Food enzymes market

The **food enzymes market** is projected to **reach USD 2.94 Billion by 2021**, at a CAGR of **7.4%** from 2016 to 2021

- **increasing interest toward health and nutritional benefits of food enzymes** among the consumers
- **Key participants** in the supply chain of food enzymes are raw material suppliers, government bodies, distributors, and end users such as the bakery, dairy, beverage, confectionery, and food processing industries. The key players involved in food enzymes market include E. I. du Pont de Nemours and Company (U.S.), Associated British Foods plc (U.K.), Koninklijke DSM N.V. (The Netherlands), Novozymes A/S (Denmark), and Chr. Hansen A/S (Denmark). Other players include Dyadic International, Inc. (U.S.), Advanced Enzymes (India), Puratos Group (Belgium), and Amano Enzyme Inc. (Japan).

Silage inoculants & enzymes industry

- silage inoculants & enzymes industry
 - Silage inoculants are used to increase the fermentation rate in silage and enzymes and to break down some of the fibre and starch in the silage.
 - growth potential (4.0%) in the next five years.
 - the global market is projected to reach \$489.05 Million by 2020, at a CAGR of 4.0% from 2015 to 2020.
 - is dominated by a few companies: ADDCON GROUP GmbH (Germany), E. I. du Pont de Nemours and Company (U.S.), Archer Daniels Midland Company (U.S.), Kemin Industries (U.S.), and Chr. Hansen A/S (Denmark) collectively accounted for a cumulative share of about 77.8% in 2014
 - Other players include companies such as Volac International Ltd. (U.K.), Agri-King Inc. (U.S.), Biomin Holding GmbH (Austria), Lallemand Inc. (Canada), Schamann BioEnergy GmbH (Germany) which together accounted for 22.2% share in 2014

Feed Enzymes Market

- gaining importance as they play an important role in **improving feed digestibility**, cost reduction, **nutrient absorption**, and better performance.
- The global market, in terms of value, is projected to **reach \$1,371.03 Million by 2020**, at a **CAGR of 7.3%** from 2015 to 2020.
- **Phytase, Protease, and Non-starch Polysaccharides** (Xylanase, β -glucanase, Cellulase, Mannanase & Pectinase

Glycobiology/Glycomics Market

- The global glycomics market was valued at **\$512.38 million in 2014** and poised to grow at a **CAGR of 12.62%** between 2012 and 2019, to reach \$928.11 million in 2019.
- The **rapid increase in research and development expenditure by pharmaceutical and biotech companies**, and **increased funding in proteomics and glycobiology research** will be the two most important growth drivers for this market in the forecast period (2012–2019).
- The **major players in this market** include Agilent Technologies (U.S.), Bruker Corp. (U.S.), Danaher Corp. (U.S.), New England Biolabs (U.S.), Prozyme Inc. (U.S.), Shimadzu Corp. (Japan), Sigma-Aldrich Corp. (U.S.), Takara Bio (Japan), Thermo Fisher Scientific (U.S.), and Waters Corp. (U.S).
- Glycosidases, Glycosyltransferases, Neuraminidases, Sialyltransferases, Other Enzymes

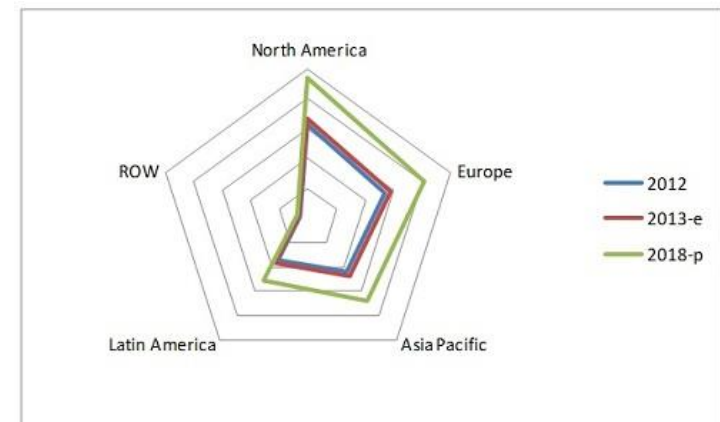
Molecular Biology Enzymes, Kits, & Reagents Market

- By application: Cloning, Epigenetics, PCR, Restriction Digestion, Sequencing
- By product: Ligase, Phosphatase, Polymerase, Protease, Restriction Endonuclease, Reverse Transcriptase
- The global molecular biology enzymes market was valued at **\$2,847.63 million in 2013** and is poised to grow at a **CAGR of 13.74%** between 2013 and 2018, to **reach \$5,420.63 million** in 2018.
- **Rapid increase in research and development expenditure by pharmaceutical and biotech companies**, and **increased funding in life science and genomics research** will be the two most important growth drivers for this market in the forecast period (2013–2018).
- **rise in the aged population** and its **susceptibility to chronic and infectious diseases** will further drive research on these ailments
- **major players** in the molecular biology enzymes market include Affymetrix, Inc. (U.S.), Agilent Technologies, Inc. (U.S.), Enzymatics, Inc. (U.S.), Illumina, Inc. (U.S.), New England Biolabs, Inc. (U.S.), QIAGEN N.V. (Netherlands), Roche, Ltd. (Switzerland), Sigma-Aldrich Co. LLC. (U.S), Takara Bio, Inc. (Japan), and Thermo Fisher Scientific, Inc. (U.S.).

Agricultural Enzymes Market

- By type: Carbohydrase, Lipase, Protease, Polymerase & Nuclease
- Application: Fertility, Growth, & Control Products
- The global agricultural enzymes market is **expected to grow at a CAGR of 7.0%** and is projected to **generate the revenue of \$301,602.5 thousand** by 2018.
- The key players covered in this report are Agrinos Inc. (Norway), Novozymes A/S (Denmark), Stoller Inc (USA), Agri Life (India), Deepak Fertilizers and Petrochemicals Corporation Ltd. (DFPCL) (India), Bioworks Inc (U.S.), Greenmax Agro Tech (India), Syngenta AG (Switzerland), Camson Bio Technologies Ltd. (India), and Aries Agro Ltd. (India).

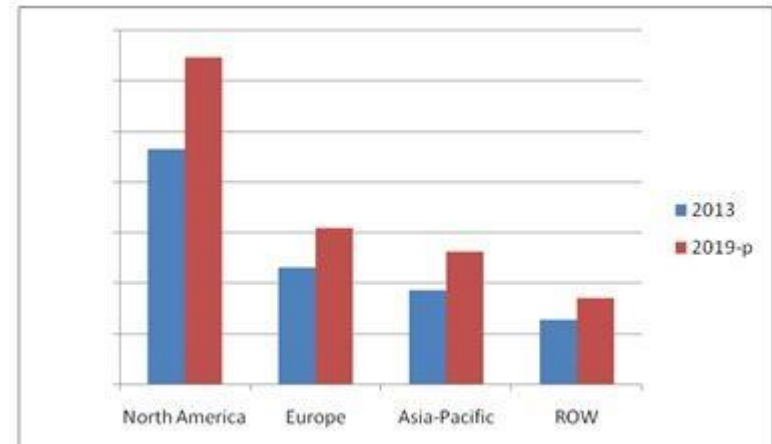
Agricultural Enzymes Market Share, By Geography (\$ '000)



Protein Hydrolysis Enzymes Market

- by Sources (Microorganisms, Animals, Plants)
- By applications (**Detergent Industry, Pharmaceuticals, Food Industry and Others**)
- The global protein hydrolysis enzymes market revenue is estimated to be valued at **\$2,767 million by 2019**.

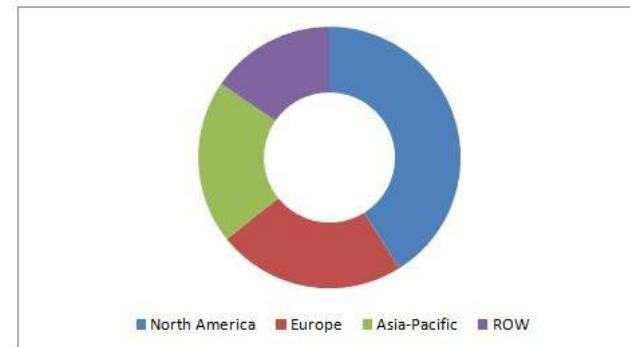
Protease Enzymes Market Size (Revenue), by Geography



Alcohol and Starch/Sugar Enzyme Market

- by Type (**Carbohydrase, Protease, and Lipase**), by Application (Industrial, Specialty)
- Alcohol enzyme and starch/sugar enzyme is primarily **utilized to produce food and beverages, cleaning agents, biofuels, pharmaceuticals, biocatalysts, as well as for research & biotechnology.**
- The alcohol enzyme and starch/sugar enzyme market is **projected to be worth \$2,238.4 million by 2018** and is expected to grow at a **CAGR of 7.9%** from 2013 to 2018.
- In 2012, North America was the largest market for the demand of starch/sugar enzymes. Rising concerns on health care and cosmetics have increased the demand of pharmaceuticals in drugs and cosmetics.

Alcohol Enzyme & Starch/Sugar Enzymes Market Revenue Share, by, Geography, 2012



Mercado de Biotech no Brasil

Estudo da Biominas - 2012

- Mais empresas Biotech focam em saúde humana do que agronegócios

- de **271 companhias de biociências**, 143 (52,8 %) são de biotech

- Saúde humana: 89 (33 %): medicamentos novos, diagnósticos, vacinas, testes genéticos,...

- Agronegócio: 84 (31 %): saúde animal, agricultura, bioenergia

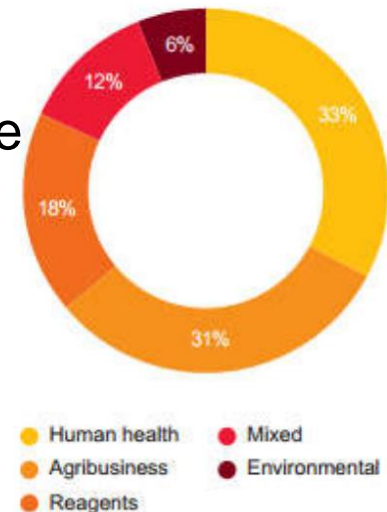
- Matéria prima: 49 (18 %) – reagentes, enzimas, para microbiologia, biopolímeros e biomateriais

- Ambiental: 16 (6 %): para bioremediação, tratamento de efluentes,...

- 75 % das 271 em SP, RJ, MG; 15 % no PR e RS

- 90 % das companhias biotech dependem de importações de reagentes e equipamentos

Companies by application



Understanding the Biotech Market in Brazil

<http://www.biotech-now.org/events/2014/05/understanding-the-biotech>.

Resende, V. - The Biotechnology Market in Brazil - February 2012

Source: Biominas/PwC Survey, 2011

Brazilian biotechnology academy

- Academic sector
 - **48 Graduate Courses** registered at CAPES
 - even larger number of Graduate Courses related to Biotechnology but registered at CAPES in other areas such Biochemistry, Genetics. Pharmacology among others
 - **52 Postgraduate Programs** in biotechnology (26 M+D, 15 M, 8 Mprof, 3 D rede) (CAPES)
- **Less than 1% of the scientific output** in Biotechnology in Brazil reaches the market
- The academic and the private biotechnology sector **do not interact**
- the number of **scientists in Brazil hired by the private sector is small** although Brazil graduates more than 1000 PhDs /year
 - United States that for this reason and others control 70% of the Biotechnology business in the world

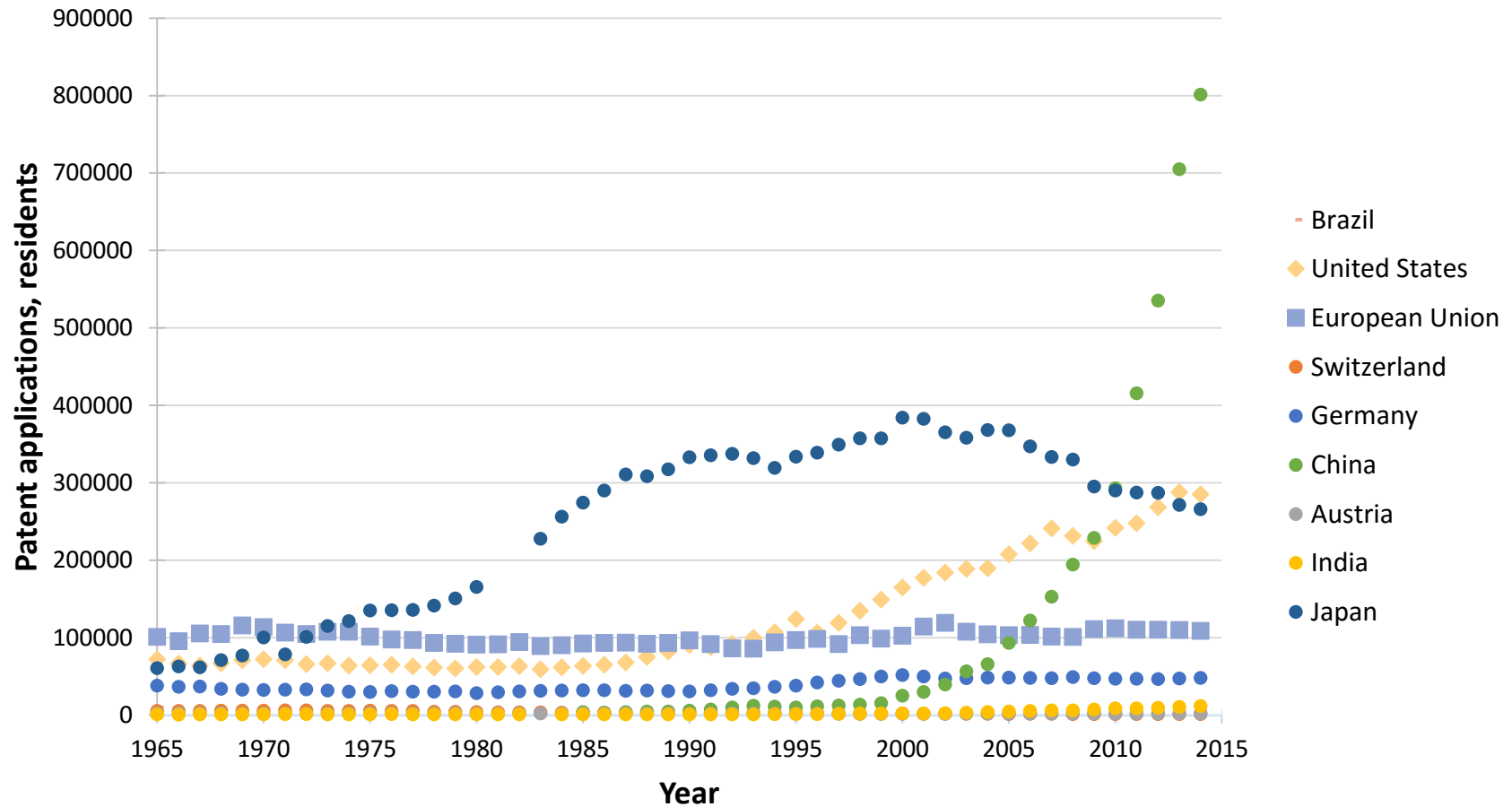
O setor de farmacêuticos no Brasil

- Brasil fica atrás de muitos países desenvolvidos e emergentes
- O setor cresce mesmo assim devido a demanda – 14 % em 2011
- **Cresce sem inovação**
 - Importa princípios ativos de outros países e comercializa produtos estrangeiros no Mercado nacional
 - Há iniciativas de juntar companhias nacionais como consórcios para a produção de “biosimilares” de anticorpos monoclonais com patentes que expiram – não há inovação nesta iniciativa
 - Brazil has no contract manufacturing organization, and not one CMO or cGMP-facility
 - Brazil cannot scale up its pharmaceutical products, nor can it properly conduct the clinical studies needed for registration at ANVISA (<http://portal.anvisa.gov.br/wps/portal/anvisaingles>)
 - O Brasil **nunca produziu um “block buster” ou registrou um produto farmacêutico na FDA** (U.S. Food and Drug Administration; <http://www.fda.gov/>).
 - Grandes corporações em geral não investem no Brasil, alegando que as leis de patentes (propriedade intelectual) não são adequados.

Governo - financiamento

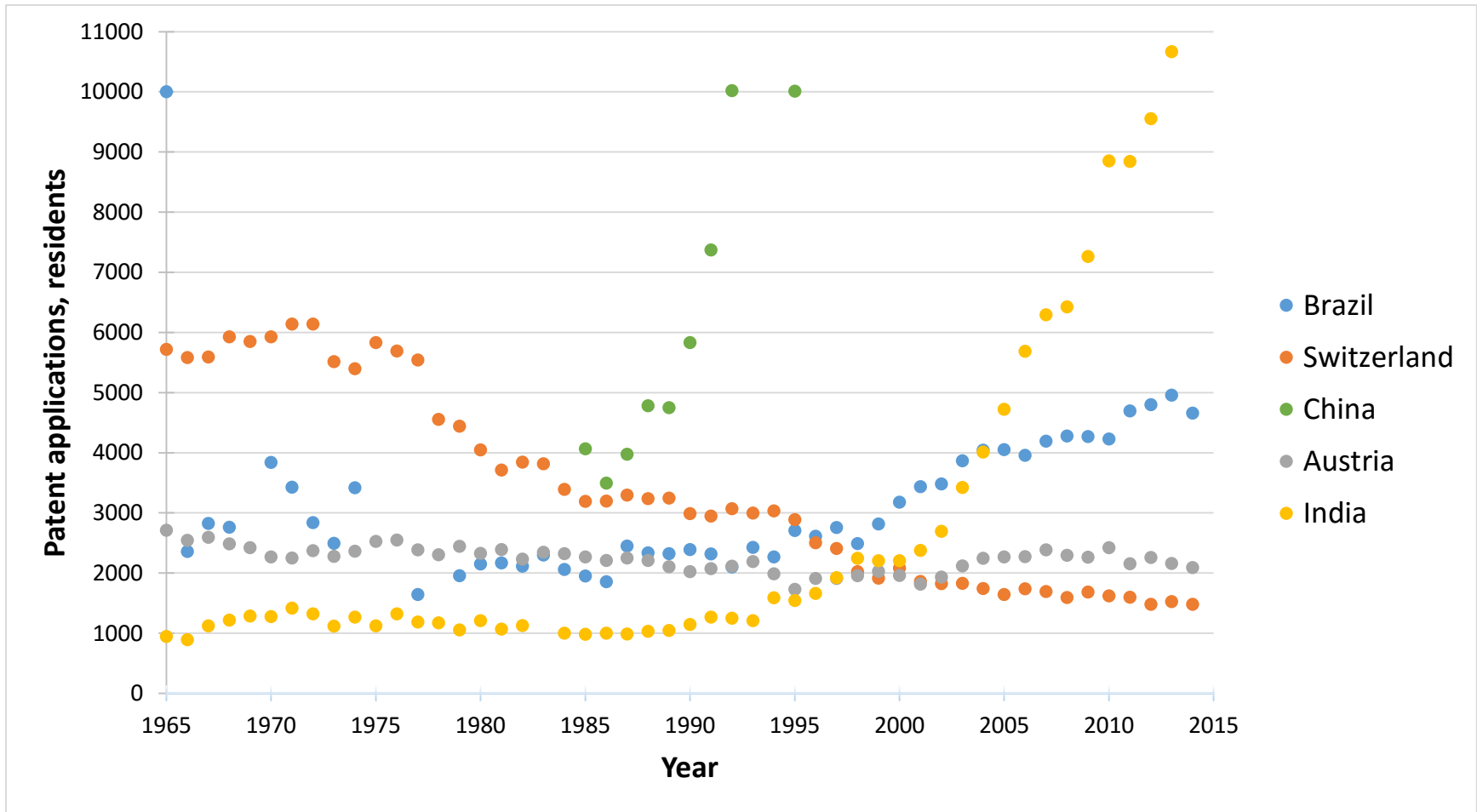
- In 2005 Brazil sanctioned an Innovation Law.
- The government is **supplying loans for biotech projects**, allowing repayment in 10 to 15 years, with subsidized interest and the absence of capital payment for 3 to 5 years.
- The federal government and private sector are **funding scholarships to train 100,000 students** in the next five years at all levels from high school to PhD.
- We estimated that in ten years 10 billion US\$ would flow to the Biotechnology sector. The decade is almost over and funds never came by.

Brasil - Patentes



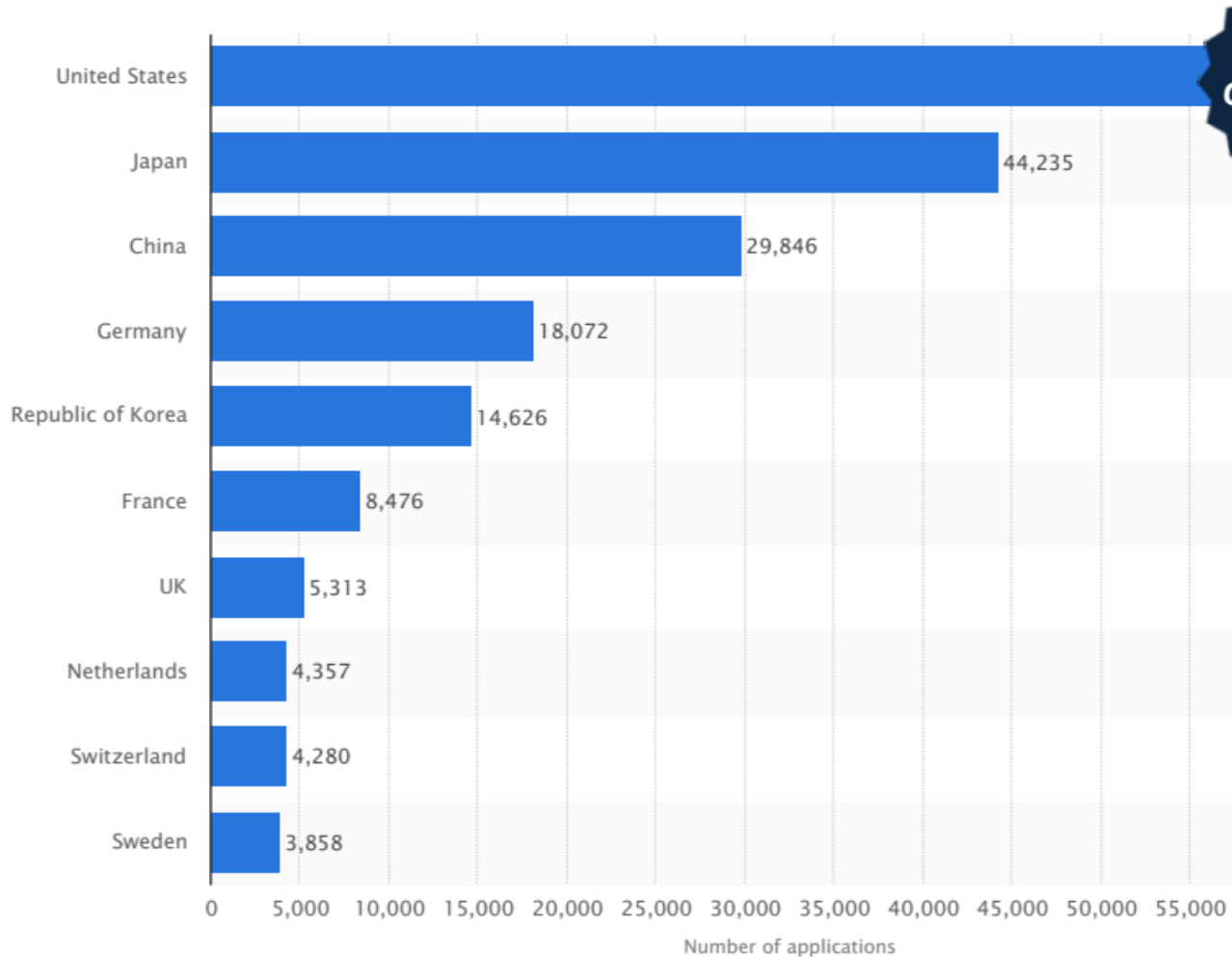
Brasil - Patentes

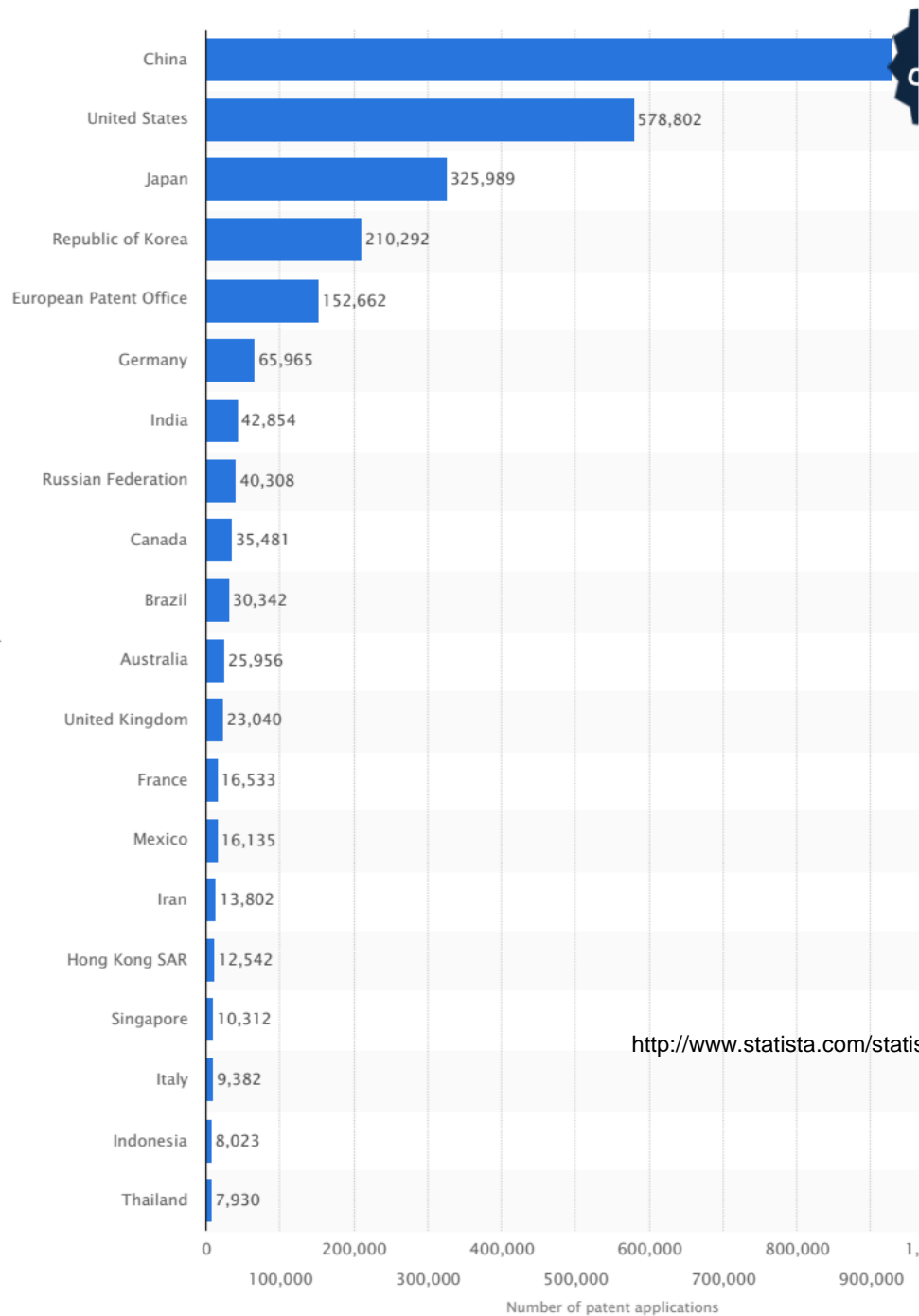
ENZITEC 2016 - Jürgen Andreas - Tecnologia enzimática no Brasil: Necessidades e desafios



International patents

Ranking of the 10 countries who filed the most international patent applications in 2015





<http://www.statista.com/statistics/257114/ranking-of-the-20-countries-with-the-most-patent-applications/>

Ranking of the 20 national patent offices with the most patent applications in 2014

TRADEMARKS

↑ **6%**

7.45 million classes
in applications



↑18.2%
China
2,222,680

↑2.7%
EU (OHIM)
333,443

↑6.7%
USA
471,228

INDUSTRIAL DESIGNS

↓ **8.1%**

1.1 million designs
in applications



↓2.3%
Republic of Korea
68,441

↑1.3%
EU (OHIM)
98,273

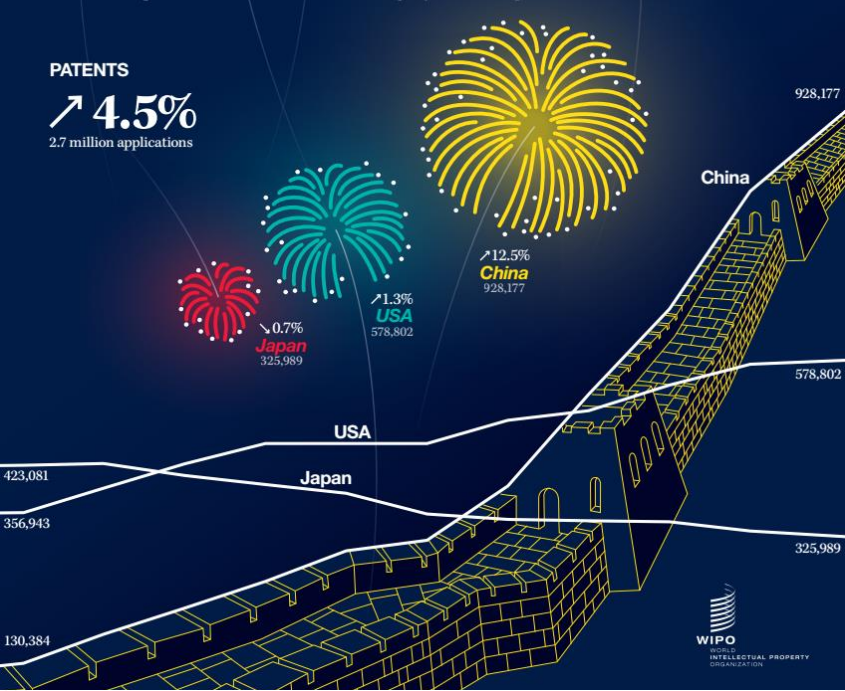
↓14.4%
China
564,555

Infographic: WIPO/LangeNetwork

Patenting activity in China in 2014 outstripped the USA and Japan combined. China's patent office received almost 1 million applications. Find latest filing trends in WIPO's World Intellectual Property Indicators report.

PATENTS

↑ **4.5%**
2.7 million applications



↓0.7%
Japan
325,989

↑1.3%
USA
578,802

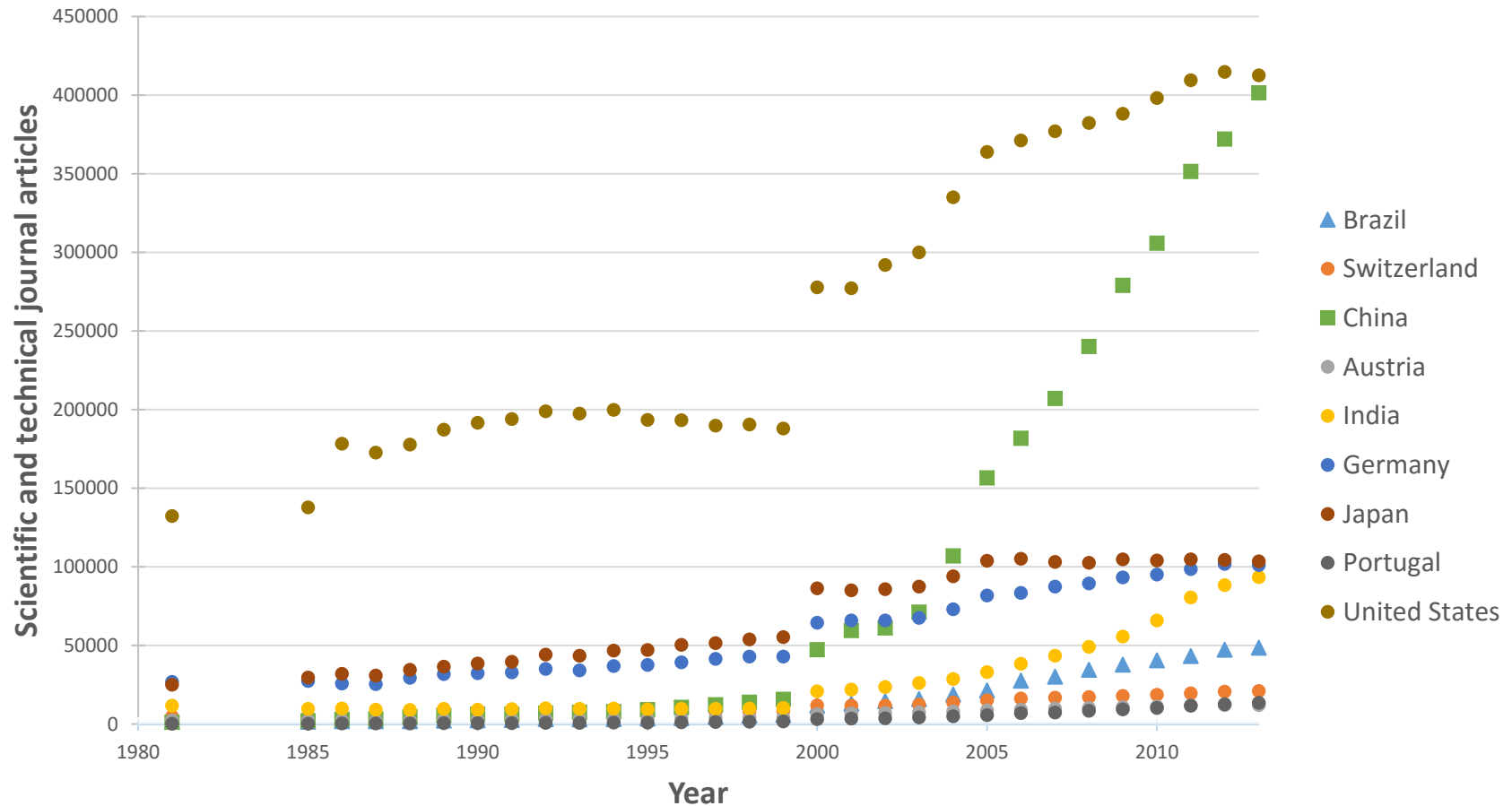
↑12.5%
China
928,177

2014 GLOBAL IP FILINGS – CHINA STILL LEADS

Patents worldwide 2014

WIPI 2015

Brasil - Scientific and technical journal articles



Intellectual property, innovation and development

Innovation – IP rules

- the twenty-first century deals in information, technology and knowledge
- No area of law has a more pervasive impact than intellectual property
 - IP rules determine who may use and control the most important assets of this new economy, in what ways and with whose permission.
- **It is too often assumed that greater IP protection yields greater development**, or that the number of patents filed can be taken as an indicator of underlying innovation.
- **The monopolies provided by intellectual property protections certainly provide incentives for innovation, but they are not the only or necessarily the best incentives** (Maskus 2000, Gallini and Scotchmer 2002)
- **Too much protection - particularly of the wrong kinds I can retard or stifle innovation.**
- **Intellectual property policy not only influences the pace of scientific innovation, but also the affordability of the products ultimately derived from that innovation.**

Brazil - IP property law

- **Prior to 1996, Brazilian law did not recognize patents on pharmaceuticals.** The manufacture of inexpensive generic medicines facilitated the creation of a national health system in which every Brazilian was promised a modern standard of care.
- **Since reforming** its intellectual property law **to comply with TRIPS***, however, Brazil has seen its public **spending on medicines dramatically increase**. This acute financial pressure is now pushing the nation's courts to redefine the constitutional right to health more narrowly than before.
- **mistakes were made as Brazil implemented the TRIPS Agreement,**
- opportunities exist to correct them

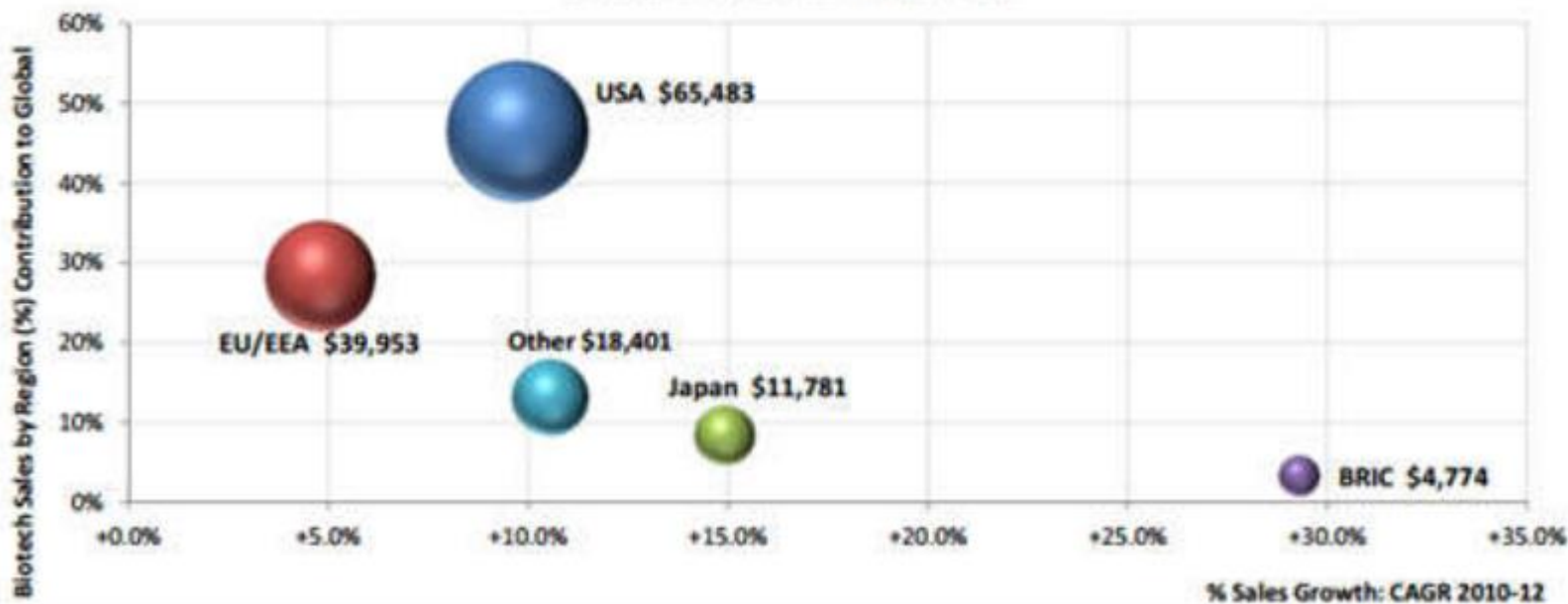
*(TRIPS Agreement) The World Trade Organization's 1994 Agreement on Trade-Related Aspects of Intellectual Property

Biotech Sales Growth among BRIC Countries (Brazil, Russian, India, and China)

29.3% compound annual growth rate
(CAGR) from 2010-2012

Biotechnology Sales & Growth by Region and Contribution to Global Market (2010-12)

Source: EvaluatePharma® (April 2014)



BRIC Biotechnology Sales Growth for the top 100 Global Pharma Companies, 2010-2012
(source: EvaluatePharma)

Brasil - Abundância de resíduos agroindustriais e florestais

- O percentual de resíduos estimados pode ser bastante alto
- somente 36 % da planta da cana de açúcar são usados para a produção de álcool e açúcar, enquanto o bagaço e a palha somam aproximadamente 64 % da biomassa
- Coco gera 85 % de resíduo após a retirada da água de coco e a polpa
- Frutas cítricas deixam 50 % de resíduo após a extração do suco

Brazilian contribution for different food and crops

Item	Brazil Production (*1000 t)	Brazil/World %
Sugar cane	768090,44	40,46
Soybeans	81724,48	29,39
Maize	80273,17	7,89
Cassava	21484,22	8,16
Citrus Fruit, Total	19734,73	14,60
Oranges	17549,54	24,61
Oilcrops Primary	16069,30	8,15
Rice, paddy	11782,55	1,60
Bananas	6892,62	6,51
Seed cotton	3417,20	4,69
Coffee, green	2964,54	33,23
Beans, dry	2892,60	12,21
Coconuts	2890,29	4,65
Cottonseed	2152,83	4,74
Sorghum	2126,18	3,83
Grapes	1439,54	1,87
Fibre Crops Primary	1378,75	4,68
Lemons and limes	1169,37	7,82
Mangoes, mangosteens, guavas	1163,00	2,73
Cotton lint	1127,68	4,60
Tobacco, unmanufactured	850,67	11,44
Oats	520,40	2,18
Rubber, natural	185,73	1,55
Sisal	150,58	53,48
Bastfibres, other	9,50	3,69

Brasil - forestry products

- Brazil is also one of the most important providers of forestry products
- In 2015 the forest production area in Brazil occupied 63,778,000 hectares
- In 2010 the planted forest area was 6,973,083 ha with the introduced planted species of Eucalyptus spp, Pinus spp, Acacia sp, Tectona sp and Populus sp..
- The estimated area for planted forests for 2015 was 7,735,772 ha (FREITAS et al. 2014)

Brazilian contribution for different forestry products

Item	Unit	Brazil production	Brazil/World %
Roundwood	m3	260756000	7,14
Industrial Roundwood	m3	142633000	7,95
Wood Fuel	m3	118123000	6,35
Wood Residues	m3	17194000	7,79
Sawnwood	m3	15367000	3,64
Other Indust Roundwd	m3	9704000	6,19
Sawnwood (C)	m3	9370000	3,12
Chips and Particles	m3	6882000	2,95
Wood Fuel(C)	m3	3340000	1,62
Plywood	m3	2365000	1,76
Wood Pulp	tonnes	15492000	9,01
Pulp for Paper	tonnes	15129000	8,41
Chemical Wood Pulp	tonnes	14507000	11,16
Bleached Sulphate Pulp	tonnes	12510000	13,17
Paper and Paperboard	tonnes	10444000	2,63
Wrapg+Packg Paper+Board	tonnes	6162000	2,86
Recovered Paper	tonnes	4481000	2,08
Printing+Writing Paper	tonnes	2621000	2,51
Wrapping Papers	tonnes	596000	3,53
Mechanical Wood Pulp	tonnes	517000	1,93
Dissolving Wood Pulp	tonnes	420000	7,11
Newsprint	tonnes	128000	0,44
Wood Pellets	tonnes	62000	0,27

Brazil – trade balance

- a **growing trade deficit** through the period of analysis
- Brazil's imports are increasing at a significant higher rate when compared to the exports
- **Exports are mainly characterized by low value-added goods**
- depends on high value-added goods produced abroad.

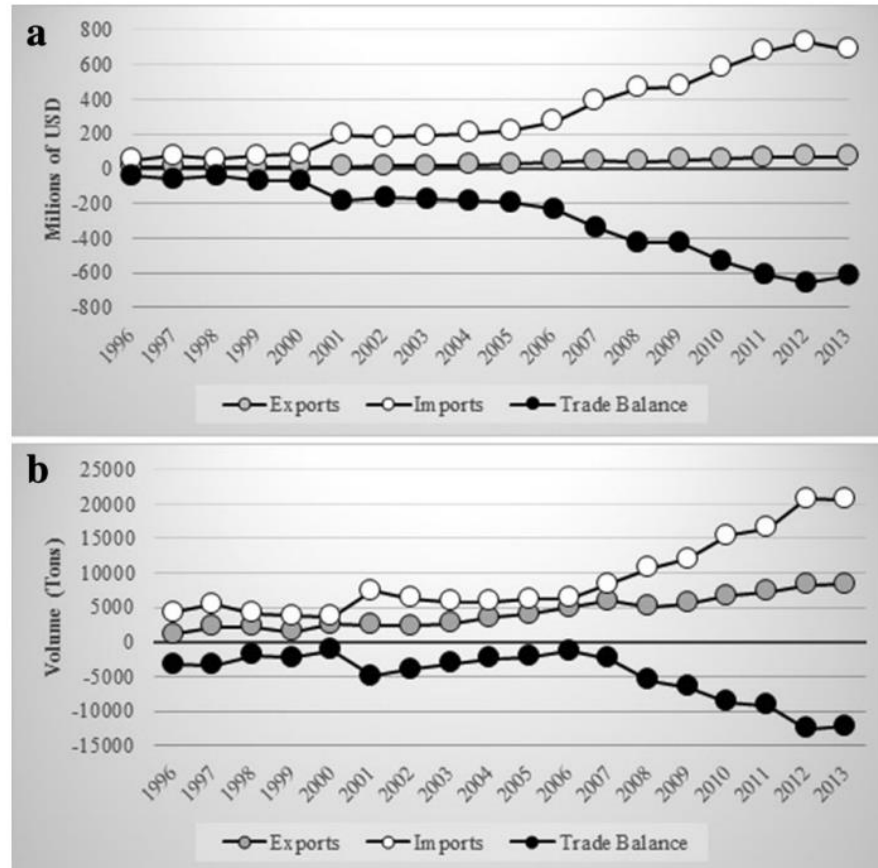


Fig. 1 Exports (*gray*), imports (*white*) and trade balance (*black*) including the thirty-one MCNs; **a** in terms of values (in millions of USD); and **b** in terms of amounts (in tons). The profile of both *graphs* showed no significant difference when the three doubtful MCN codes were not considered (data not provided)

Why Brazil has one of the most important biodiversity of the world but has a negative trade balance in enzyme market?

A comunidade científica

Produção científica acadêmica - Tecnologia enzimática

- CNPq: até 2013 os PPG 310.000 MSc e 172,000 PhD

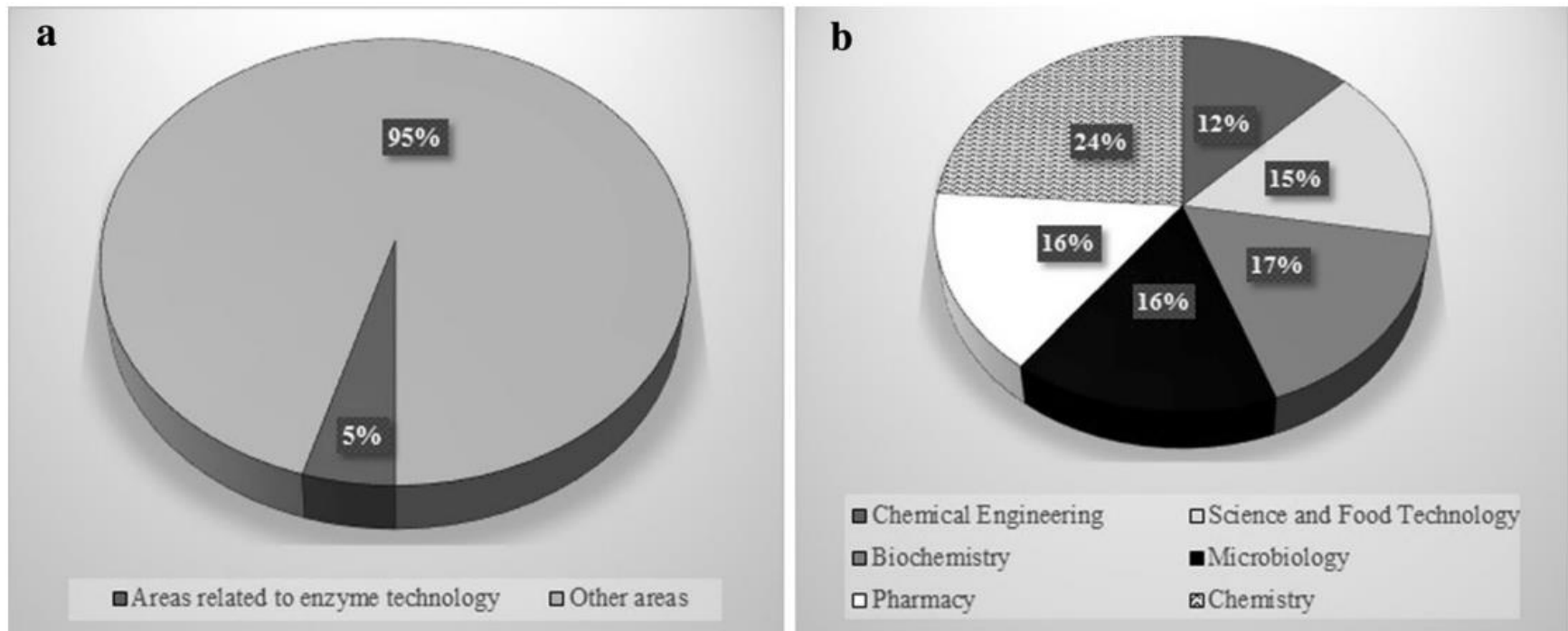


Fig. 3 a Percentage of master's degrees granted by Brazilian postgraduate programs in areas related to enzyme technology, **b** percentage distribution per area of the master's degrees granted in areas related to enzyme technology

A comunidade científica

Produção científica acadêmica - Tecnologia enzimática

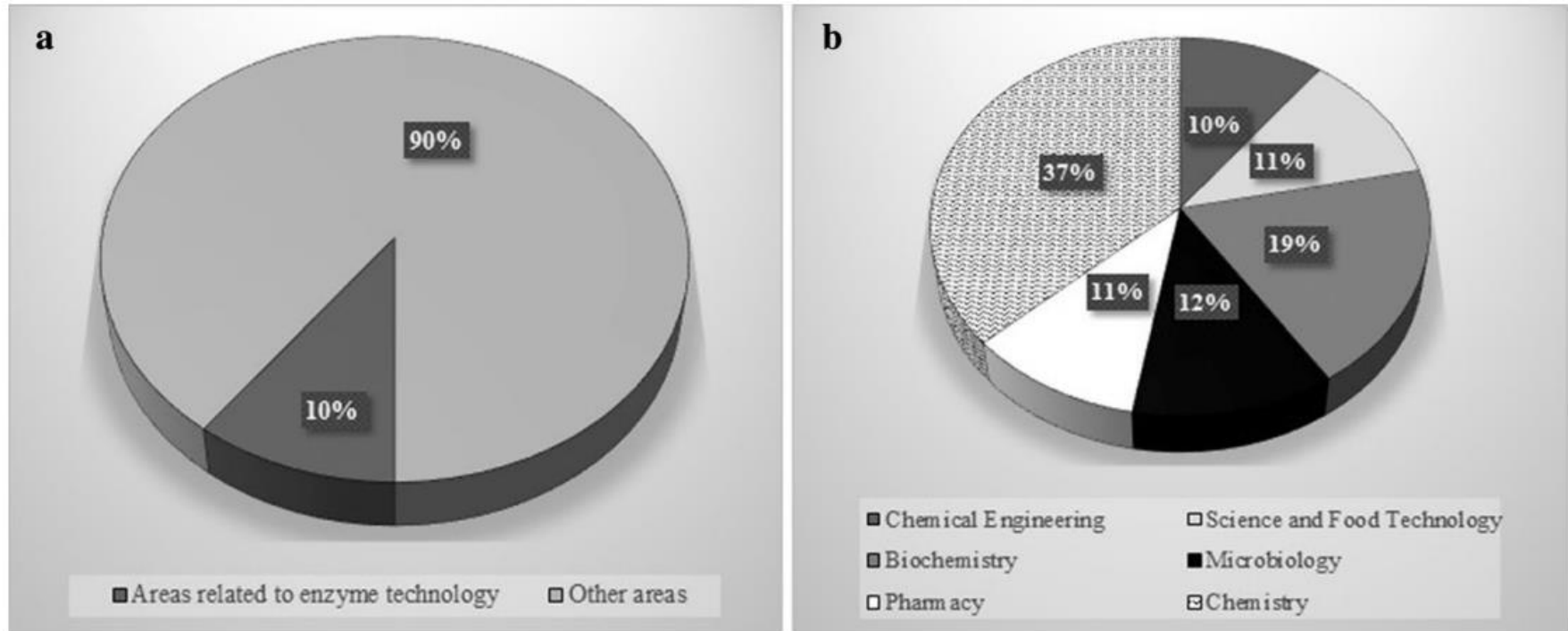


Fig. 4 **a** Percentage of doctoral degrees granted by Brazilian postgraduate programs in areas related to enzyme technology, **b** percentage distribution per area of the doctoral degrees granted in areas related to enzyme technology

Especialização da comunidade científica

CV Lattes of Brazilian researchers Phrases related to enzyme technology

Accurate phrases	DScs	Other researchers
Enzyme technology	108	38
Enzyme production	566	481
Enzyme immobilization	206	65
Enzymology	345	143
Enzyme kinetics	276	93

“Other researches” includes MSc, graduate and undergraduate students, and others



MCN	Keyword	Number of DSc + Other researchers "Production of (keyword)"
23099060	Xylanase	200
30021033	Urokinase	0
35071000	Rennet	9
30039021	Streptokinase	0
30049011		
35079023		
35079024	Streptodornase	0
35079025	Streptodornase	0
	Streptokinase	0
30039023	Deoxyribonuclease	2
30049013		
35079032	Asparaginase	28
30049012		
35079011	Alfa-amylase	76
35079019	Amylase	149
35079021	Fibrinolysin	0
35079022	Bromelain	4
35079026	Papain	2
35079029	Protease	167
35079031	Lysozyme	1
35079041	Cellulase	194
30021032	Plasmin	0
	Fibrinolysin	0
35079042	Transglutaminase	14
35079049	Protease	167
	Collagenase	13
30039029	Pancreatin	0
	Lipase	371
	Protease	167
	Amylase	149
35079039	Glucose oxidase	2
	Catalase	8
	Cellulase	194
	Pectinase	50
	Lipase	371

Correlation of the MCN codes with the scientific production of Brazilian researchers

Brazilian research focuses mainly on **“enzyme commodities”**

Large scale produced enzymes with low market prices

These Enzymes are used in:

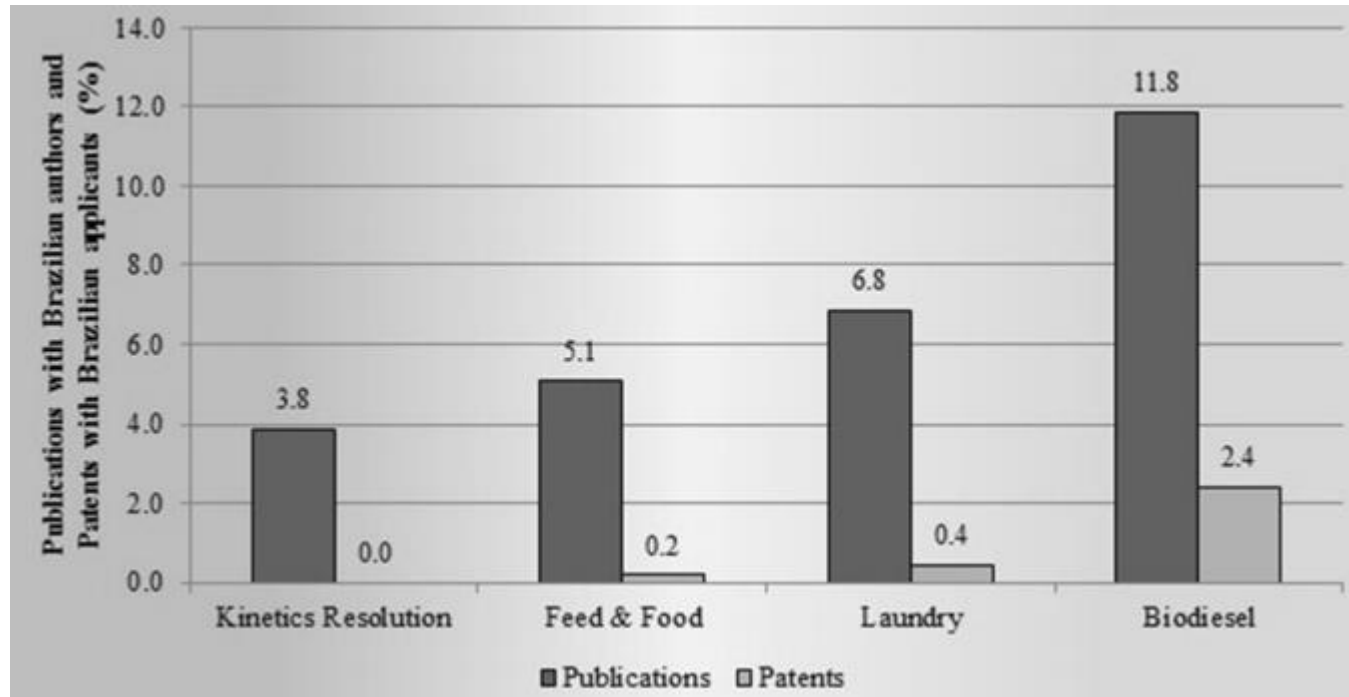
Detergents composition

Food industry

Bioenergy production

MCN Mercosur Common Nomenclature codes comprise eight digits, the first six being formed by the Harmonized System (an international standardized system of names and numbers to classify traded goods) and the last two being specific to the Mercosur context.

Brazil – Publications and Patents on lipases



Enzyme technology – keyword web of Science / scopus

buscas	webofscience	scopus	webofscience	scopus
field	tópico	tópico	tópico	tópico
anos	todos	todos	todos	todos
keyword	enzyme technology	enzyme technology	"enzyme technology"	"enzyme technology"
entry	16.090	681,116	341	7340
refine	Brazil	Brazil	Brazil	Brazil
ref entry	45	26,858	1	248
patents	2.851	687,575	43	1616
ref patents	1	7655	0	18
territory Brazil		16870	6	186
territory Brazil patent		6	0	0

Oportunidades

- Diversidade de biomassa
- Vastos resíduos de biomassa e industrial (agroindustrial)
 - Prevenção do acúmulo de resíduos poluentes
 - Uso de fontes para meios de cultura baratos para a produção de enzimas
- Valorização no conceito da biorrefinaria e química verde
 - Obtenção de produtos como plataformas químicas (“building blocks”)
- Focar em enzimas especiais (non-commodity enzymes)

Green Chemistry - Sustainability

A chemical process mediated by enzymes fits into, at least, seven Principles of Green Chemistry:

- waste and pollution prevention through real-time analysis
- use of less hazardous and less toxic chemicals and reactions
- safer products
- energy efficiency (low temperature, low pressure)
- use of renewable materials
- use of catalysts instead of stoichiometric reagents (catalytic process)
- safer processes

Implies also in

- less derivatives and side reactions
- reduced use of auxiliaries, use of green solvents (Safer Solvents and Auxiliaries)

All of the 12 principles of Green Chemistry may be achieved by the use of biocatalysts

(Anastas & Warner 1998)

Conclusions

O **balanço comercial** de produtos relacionados com enzimas é negativo e **tende a ficar mais negativo** ainda

Não falta pessoal treinado nesta área, porém a comunidade de pesquisa não está saturada

O **aumento** do número **de pesquisadores não é acompanhado** de índices **de inovação** proporcionais

Falta de demanda de empresas privadas

A maioria das exportações Brasileiras é composta de **mercadorias / bens não-industrializados ou de baixa tecnologia.**

Perda de competitividade das indústrias é resultado de falta de inovação

Investimentos públicos e privados em ciência e tecnologia são necessários

Conclusions

Fica evidente que **uma aproximação maior** entre as universidades e a indústria é necessária

Um **amadurecimento de ambos os lados** Academia / Indústria é necessária (menos burocracia de um lado, mais coragem do outro)

Melhoras na política de financiamento são necessários – mais objetividade, menos burocracia, porém mais controle das metas

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Aos organizadores do XII ENZITEC 2016

Obrigado

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