SUSTAINABLE DEVELOPMENT GOAL 9

INDUSTRY, INNOVATION AND INFRASTRUCTURE

CONTRIBUTIONS OF EMBRAPA

Ana Cristina Richter Krolow
Élen Silveira Nalério
Fernando Teixeira Samary
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Technical Editors

Embrapa

Brazilian Agricultural Research Corporation
Ministry of Agriculture, Livestock and Food Supply

Sustainable Development Goal 9

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Embrapa
Brasília, DF
2020

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1st Edition
Digital publication – PDF (2020)

Cataloging in Publication (CIP) data
Embrapa

Industry, innovation and infrastructure: contributions of Embrapa / Ana Cristina Richter Krolow... [et al.,], technical editors. – Brasília, DF: Embrapa, 2020.
PDF (49 p.) : il. color. (Sustainable development goals / [Valéria Sucena Hammes ; André Carlos Cau dos Santos] ; 9).

Translated from: Indústria, inovação e infraestrutura: contribuições da Embrapa. 1st edition. 2018.
ISBN 978-65-86056-21-1

1. Sustainability. 2. Sustainable agriculture. 3. Agricultural research. I Nalério, Élen Silveira. II. Samary, Fernando Teixeira. III. Lima, Leandro Kanamaru Franco de. IV. Embrapa. Intelligence and Strategic Relations Division. V. Collection.

CDD 658.5

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Foreword

Launched by the United Nations in 2015, 2030 Agenda for Sustainable Development is powerful and mobilizing. Its 17 goals and 169 targets seek to identify problems and overcome challenges that affect every country in the world. The Sustainable Development Goals (SDG), for their interdependent and indivisible character, clearly reflect the steps towards sustainability.

Reflecting and acting on this agenda is an obligation and an opportunity for the Brazilian Agricultural Research Corporation (Embrapa). The incessant search for sustainable agriculture is at the core of this institution dedicated to agricultural research and innovation. Moreover, sustainable agriculture is one of the most cross-cutting themes for the 17 goals. This collection of books, one for each SDG, helps society realize the importance of agriculture and food in five priority dimensions – people, planet, prosperity, peace and partnerships –, the so-called 5 Ps of 2030 Agenda.

This collection is part of the effort to disseminate 2030 Agenda at Embrapa while presenting to the global society some contributions of Embrapa and partners with potential to affect the realities expressed in the SDG. Knowledge, practices, technologies, models, processes and services that are already available can be used and replicated in other contexts to support the achievement of goals and the advancement of 2030 Agenda indicators.

The content presented is a sample of solutions generated by agricultural research at Embrapa, although nothing that has been compiled in these books is the result of the work of a single institution. Many other partners joined in – universities, research institutes, state agricultural research organizations, rural technical and extension assistance agencies, the Legislative Power, the agricultural and industrial productive sector, research promotion agencies, in the federal, state and municipal ranges.

This collection of books is the result of a collaborative work within the SDG Embrapa Network, which comprised, for 6 months, around 400 people, among editors, authors, reviewers and support group. The objective of this initial work was to demonstrate, according to Embrapa, how agriculture research could contribute to achieve SDGs.

It is an example of collective production and a manner of acting that should become increasingly present in the life of organizations, in the relationship

between public, private and civil society. As such, this collection brings diverse of views on the potential contributions to different objectives and their interfaces. The vision is not homogeneous; sometimes it can be conflicting, just as society's vision about its problems and respective solutions, a wealth which is captured and reflected in the construction of 2030 Agenda.

These are only the first steps in the resolute trajectory that Embrapa and the partner institutions draw towards the future we want.

Maurício Antônio Lopes
President of Embrapa

Preface

This work – *SDG 9: Industry, innovation and infrastructure: contributions of Embrapa* – is part of the collection Sustainable Development Goals: contributions of Embrapa, making up its volume 9. By focusing on building resilient infrastructures, seeking to promote broad and sustainable industrialization, and fostering innovation, the United Nations SDG 9 articulates with all those goals aimed at eliminating poverty in all its forms.

Embrapa plays a very important role in all SDGs context, since its mission is to seek and promote solutions for agribusiness in Brazil. It contributes with technologies, innovations and services to all SDGs. Embrapa also collaborates with the achievement of the Brazilian goals, which aim at the development of sustainable structures to guarantee employment, income and social justice.

This work aims to discuss and present Embrapa's contributions to SDG 9. Among the targets of SDG 9 in the United Nations' documents are:

> 9.5 –Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development. Also, 9.b – Support domestic technology development, research and innovation in developing countries including by ensuring a conductive policy environment for, inter alia, industrial diversification and value addition to commodities[1].

The first chapter has a brief exploration of SDG 9, with observations on the global and Brazilian contexts, as well as considerations specific to Embrapa scope. Chapter 2 addresses the demands and opportunities for Brazilian agroindustrial innovation and development. Chapters 3 and 4 deal specifically with Embrapa's contributions to SDG 9 targets. The strengthening of agricultural research occurs through actions to qualify the project portfolio, in qualification, training and improvement of Embrapa's research framework, as well as in the alignment of research projects in relation to the Brazilian society demand. Innovation of agricultural research is seen through research and development actions and

[1] Available at: <https://sdgs.un.org/goals/goal9>.

technological solutions that add value to products from national production chains. Chapter 5 shows a summary of the discussed topics and discusses some solutions and challenges in Research & Development (R&D).

Technical Editors

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Chapter 1

Sustainable Development Goal 9 in the world, in Brazil and at Embrapa

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Sustainable Development Goal 9

The United Nations (UN) Sustainable Development Goal 9 (SDG 9) addresses the theme "industry, innovation and infrastructure". This goal paves the way to induce construction and strengthening of resilient infrastructures and the promotion of not only inclusive and sustainable industrialization, but also innovation development. These three structuring areas – resilient infrastructures, inclusive and sustainable industrialization, and technological advancement – are the SDG 9 goals for the inclusive development of nations. These structuring areas of SDG 9 have formed the essential elements of the "Prosperity" area of 2030 Agenda for Sustainable Development (Machado Filho, 2017).

The Brazilian position in relation to the Post-2015 Development Agenda (Brasil, 2014) established the sustainable patterns of consumption and production, in which public policies, new partnerships and strategies should be directed towards this end, aiming at ways to combat poverty. In this document, the substantive elements were listed as part of the efforts to implement the sustainable development goals, establishing that nine elements are considered for industry and infrastructure.

Given the definition of these structuring areas, the interaction between SDG 9 and the strategic objectives defined by Embrapa in its VI Master Plan can be visualized in 4 of the 12 objectives established as RD&I results, in fulfillment of its mission and range of outlined by 2034, which are:

(a) "To broaden the knowledge base and the generation of assets that accelerate the development and incorporation of agrifood and agroindustrial systems of advanced solutions based on emerging sciences and technologies "; b) "Develop,

adapt and disseminate knowledge and technologies in automation, precision agriculture and information and communication technologies to increase the sustainability of production systems and add value to agricultural products and processes"; c) "Promote the advancement of knowledge and technological solutions focused on expanding the contributions of agricultural research to the integration between food, nutrition and good health"; d) "Generate knowledge and technologies and propose strategies, locally adapted, that contribute to the productive inclusion of family farming" (Embrapa, 2015, our translation).

Based on this interaction, Embrapa, as an agricultural research institution, identified three elements in which its contribution concentrates: a) strengthening institutions and mechanisms to support industrial production, technological upgrading and value added; (b) promoting sustainable industrial development based on energy and efficient resources and environmentally friendly industrial processes, including progressive elimination of harmful chemicals, waste and pollution, minimizing the use of materials and maximizing material recovery, with cooperation and technology transfer to support such development; and (c) supporting innovation in enterprises with a view to creating and incorporating sustainable production technologies.

Based on this identification, the contributions and Embrapa insertion in the context of SDG 9 are presented.

SDG 9 and its relationship with the world

One of the main UN goals is to "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (United Nations, 2018). There is a great diversity of productive alternatives capable of providing food, labor and income for less developed communities in the rural world. These alternatives, once improved with technology and technical assistance, tend to grow beyond the subsistence goal in some locations, rapidly transforming productive initiatives into real business.

In productive activities, many stakeholders, mostly rural workers, are often involved, but not always adequately trained and paid, but motivated enough to accept and seek technology and options for improving family's living conditions. In many regions of the world, women and their children devote themselves to pastoral activities to grazing goats, sheep, cattle, swine and poultry, from which

they derive the base of their protein diet, in addition to part of the income for the other family needs.

When primary production reaches the limit of viability in the small-scale rural property, which is most often due to the small size of the productive area, availability of inputs and deficiencies of employed technologies, options to overcome this difficulty are necessary. A viable option in many developed communities to overcome this limit (with the aid of technology/technical assistance) is to improve efficiency and productivity by area and product quality. A second option is to process this raw material, transforming it into durable products that can be marketed off-site.

In livestock activities, this transformation involves adopting and improving some fundamental processes. Concerning dairy and eggs, it occurs by refrigeration and processing; meat, it occurs by slaughter, refrigeration and processing. It should always be taken into account that the processing step is quite complex. It depends on processing units and the use of appropriate, efficient and fully legalized process. However, in spite of bringing complexity, this step improves the generation of income and jobs, providing greater power to the communities. For this reason, this step has been encouraged by public power, with the creation of dedicated policies.

On a global scale, developed countries have set ambitious plans to sustain their market positions, with an emphasis on investment in new technologies and in every more complex ingredient, especially in the factors historically presenting competitive advantages. Specifically, the policies of the more developed countries define the segment of industrialized foods with higher value added as strategic. Hence, they concentrate their investment in areas of technology and ingredients with the potential of being prominent in the food market for good health and well-being. In the latter case, formulations derived from biotechnology, nanotechnology and bioactive ingredients (Madi; Rego, 2014), among others, are being used.

SDG 9 and its relationship with Brazil

After the long privilege period of Brazilian agricultural policy for large and medium-scale producers, spatially located in the South and Southeast regions and with products for export, the 1990s witnessed the partial modification of the action scope of intervention mechanisms towards the rural area. From the 1990s,

important changes occurred in vast sectors of Brazilian agricultural policy. Since then, the programs outline began to increasingly be characterized by the inclusion of social segments hitherto practically reneged on by agricultural policies, such as family farmers, fishermen, natives and *quilombolas*, among others. Insertion, recognition and legitimization of differentiated activities in the field (such as agro industrialization on a family, rural tourism, handicrafts and power generation scale) became recognized and prestigious within various government programs.

The year of 2003 faced the expansion of forms of intervention in the Brazilian rural area and the inclusion of small rural enterprises to improve agricultural production, the federal government implemented the Programa de Agroindustrialização da Agricultura Familiar (Agro industrialization for Family Farming Program). At the time, Brazilian family farming was immersed in an intense process of productive socialization processes with a reduction of its autonomy and income. Some studies try to show that this is a result of an environment characterized by increasing socioeconomic vulnerability. The globalization expansion of agrifood system and alteration of regulatory and institutional framework have greatly influenced this reality. With the creation of this new competitive environment, the direct threat to family farming participation was evident. The general reality was characterized by the increasing need to extract profitability. This was achieved by means of gains in scale, which in turn were obtained by the use of modern inputs (genetic and chemical) and by the use of large machinery and other technological innovations. This became the basic condition for maintenance or entry into the markets, hindering the small-scale agricultural enterprises (Wesz Junior, 2012).

Since then, various denominations have been used to indicate industrialization forms. Thus, terms such as small-scale agro-industry, family agroindustry, small-scale agroindustry, homemade agroindustry, artisanal agribusiness, medium and large, and food processing industries came up. Guanziroli (2010 cited by Santos, 2014) presents contribution in this sense. Here are some of these conceptual contributions regarding agroindustry:

- Home agroindustry – it does not have specific equipment for processing; the priority is self-consumption and sale of the surplus in local markets; it works in the informality and does not have special sanitary control, except the sanitation normally used in family food preparation.
- Artisan family agroindustry – this type of enterprise elaborates products typical from cuisine of a certain region, whose production is directed to the local/regional market; it follows the Good Manufacturing Practices (GMP)

as it aims to improve the sanitary quality of its products; its final product has an artisan character, linked to an intergenerational knowledge.

- Small-scale family agroindustry – conventional small-scale agribusiness, emerged as an income opportunity for a family or group of families; it sells to regional and/or national markets; the manufacturing parameters are the same as those of the large industries with regard to sanitary control of the final product; there is no specific knowledge to be valued, but a know-how learned in the food technology area.

In addition to the artisanal agroindustries – despite the potential of its agroindustrial production – Brazil is a strong producer of commodities, that is, a significant part of its production is directed to fresh products export, having its price determined by international exchanges. In 2016, data from the Associação Brasileira das Indústrias da Alimentação (Brazilian Association of Food Industries – Abia) showed that the sectors with the highest growth rates in relation to the previous year were coffee and sugar, with a 9.4% index, followed by processed vegetable and juices, with 4.4%, and oils and fats.

The relative quantity of micro, small, medium and large-scale enterprises of the food and beverage industry in the European Union, region of greater global representativity, is very similar to Brazil. In Brazil, the food and beverage industry is considered one of the strategic industries. Data show that this was the industrial segment with the largest direct job creation (1,621 million) in a contingent of 35,200 companies (Associação Brasileira das Indústrias da Alimentação, 2016). In 2011, the majority of the sector was made up of micro (81.1%) and small companies (13.5%). The average companies represented 4.0% and the large ones, 1.4% of the sector.

SDG 9 and Embrapa

Within its structure of Research Units, studies try to increase the competitiveness and sustainability of Brazilian agricultural production. In this sense, Embrapa is constantly focused on productivity, with environmental aspects as parameters and agronomic and veterinary techniques compatible with the best available ones.

The work developed by the Embrapa bases on the feasibility of research solutions that imply innovation and sustainability for agriculture. Throughout the years, Embrapa has developed technological solutions based on the real Brazilian

challenges. As a result, the Brazilian agricultural sector is one of the most efficient in the world and due to similar edaphoclimatic conditions, Embrapa has also taken these solutions to other countries, especially those in Africa. New challenges have been arising and will emerge and guide Embrapa's future research; for this purpose, this it was created.

This public research institution has relevant action within the Brazilian territory, bringing significant savings to the productive sector focused on commodities. However, Brazil has similar edaphoclimatic characteristics to many African countries. Thus, it is strategic to take development to other countries lacking in technology and genetic material.

Embrapa, through agricultural research, contributes to commodity production, and research results have been relevant in major agricultural commodities, such as soy, wheat, maize, beef, coffee, cotton and timber. Important Brazilian agriculture commodities have become prominent in the national market, with the development of research coordinated by Embrapa in the collaboration of important universities and research institutes. For example, national coffee productivity has grown significantly in the last 20 years, affecting domestic consumption and exports (Embrapa, 2015). Similarly, fish from Brazilian mainland, aquaculture has shown significant advances in recent years. This growing may be associated with increased consumption and high consumer demand. Research developed by Embrapa has contributed by providing technologies and transferring important knowledge to the increase of production and industrial processing of Brazilian aquaculture. The Aquabrasil project, for example, stood out for promoting a technological leap in Brazilian aquaculture, based on meeting the main production chain demands. The strategies adopted by the project defined advances in obtaining good fish-seed quality through genetic improvement, in the provision of environmentally safe feed with the highest livestock yield, in the identification and sanitary control of animals (integrated with production systems) and in the management associated with an efficient environmental management, which contemplated the adoption of Good Management Practices (GMPs) to ensure fish production that could be processed by agroindustry (Embrapa, 2017).

Final considerations

Contribution from Embrapa stands out regarding the strengthening of resilient infrastructures and the development of inclusive and sustainable industrialization. Embrapa's works focus on providing technological solutions that imply innovation

and sustainability for Brazilian agriculture, considered one of the most efficient in the world.

Since it is an emerging need to reduce food waste and losses from industrial processing to conscious consumption, Embrapa's strategic guidelines have contributed to this demand by inducing research aimed at determining alternative and intelligent ways to industrial exploitation.

There is still a long way to go, especially to work in all the agroindustrial sectors considered important and with reflections of sustainable inclusion in the world scenario for food security of the population. The research carried out by Embrapa have been relevant to the main agricultural commodities in Brazil, as a result of a commitment to the established goals and the comprehensiveness of research that is present in almost all Brazilian states, working on different themes and sectors of great impact for the Brazilian economy.

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Chapter 2

Demands and opportunities for agroindustry innovation and development

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Introduction

The hunger issue is one of the realities considered by agricultural research to achieve the Sustainable Development Goal 9 (SDG 9). Overall, it has grown again. In 2016, the lack of food affected 11% of the global population, that is, there were 815 million people under malnutrition situation in the world; in 2015, there were 777 million people under hunger situation (The state..., 2017). The growth of world's hunger relates to the consequences of armed conflict, climate change and the deterioration of some economies. In Latin America and the Caribbean, 6% of the regional population is starving. This corresponds to 42.5 million people.

Given this bleak picture, much can be done to reverse it. Through its technologies, Embrapa's participation plays a fundamental role in the viability of losses and wastes reduction by means of the best food use.

Researches carried out by Embrapa, in partnership with other institutions, have shown the possibility of taking advantage of discarded materials for the production, for example, of biocomposites which, in association with other materials, can be used as food packaging, food protection films, among other applications. Therefore, only the generation of innovative technologies and solutions – aiming at obtaining raw materials with high nutritional and sanitary quality, advanced industrial technologies, innovative equipment that generate productivity increase with sustainability, both in the field and in the industry, promoting increase in income for the family-based producer or industrialist or commodity producer – will lead to losses and wastes reduction in Brazil and in the world.

Food loss and waste in Brazil and in the world

Data presented by Benítez (2016) indicate that loss and waste of 1,300 billion tons of food occurs annually in the world. In Latin America and the Caribbean alone, food wasted from retail could feed more than 30 million people. These losses occur in all productive sectors, from production to harvesting, post-harvesting, transportation, distribution, marketing and consumption. In Latin America, 15% of food is wasted annually, accounting for 6% of all world losses. As emphasized, the distribution of these losses and waste occurs at all food chain stages: 28% is wasted by consumers; 28%, in production; 17%, in market and distribution; 22%, during handling and storage; and 6%, in processing.

Given these numbers, the processing industry is the one that least wastes food. These losses relate mainly to raw materials unfit for processing due to poor sanitation, seeds, bones, skin, feathers, etc., and industry makes the most of the raw materials received.

Waste generation

In relation to sustainability, a broader vision is inherent in the whole use of the products. It is implicit that in the agroindustrial transformation waste production occurs, although it is the sector with the lowest losses and waste. In most cases, there is disposal of these materials or use as fertilizers. Non-use of waste can bring about environmental and economic implications, but above all, it has a social impact due to the non-availability of products suitable for consumption. There is a lot of protein loss in the fish industry which, compared to the beef sector, still has a lot to develop; as well as in the dairy sector many proteins are discarded due to the low serum use. There is fiber losses in the segment of minimally processed vegetables by discarding parts considered non-commercial. These are some challenges that surround waste use. For example, in agroindustrial fish processing a large waste amount is generated. In general, from 60% to 70% of fish submitted to industrial filleting is discarded, taking into account the meat yield of the fillet made available to the final consumer. Carcasses, viscera, skin and scales are often used in greasing with the aim of producing oil and fishmeal. Not all fish processing establishments have such a structure, which creates problems for the management of discarded material during industrialization.

Embrapa has developed research aimed at generating technologies focused overall use of fish. In addition to adding market value to products from fisheries

and aquaculture, the reuse of waste can minimize environment impacts. In this scenario, the Embrapa develops research aimed at the utilization of tilapia residues. Among the main goals, viability evaluation stands out as well as stability of the mechanically separated meat, elaborated with industrialization residues of these fish. Additionally, the products generated with this technology tend to reach a greater public due to the possibility of inserting fish in social programs and to reverse revenues for the own processing industry.

Importance of family agroindustries and their difficulties

Agroindustries are a contemporary synthesis, representing the union between the relations of production, management, administration and inspection, adequate to the market demands. Inserting agricultural family into productive chains and agroindustrial systems can be turned into efficiency for the technical-productive modernization, presenting itself as a survival strategy of the family units based on adequate management techniques for each type of activity developed in agriculture (Lima et al., 2015).

The difficulties inherent to the development process of productive chains basically relate to: a) difficulty and lack of organization of the stakeholders; b) difficulty and lack of production linkage; c) difficulty and lack of legalization of production and processing activities; d) difficulty and lack of access to factors of production (land, capital, skilled labor, technology); e) difficulty to assemble schedule, logistics, slaughterhouses, fridges, agroindustries, product portfolio, work team and sales.

These difficulties are common among smallholders throughout Brazil; however, there are also good examples of insertion into the production chain in poultry and swine in the South. In the register of the Secretaria de Desenvolvimento Rural, Pesca e Cooperativismo (Department of Rural Development, Fisheries and Cooperativism – SRD) in Rio Grande do Sul state, in the first half of 2017, 77 agroindustries were included in the Programa Estadual de Agroindústria Familiar (State Program of Family Agroindustry – Peaf) (Daroit, 2017). This increase in family agroindustries is due to the attempt to income growth in the property, avoiding the rural exodus, keeping the young people in the field to guarantee succession in the property or even to flee the city and find use for the fresh production in moments of difficulty in selling.

It is difficult to industrialize products of animal origin, which could be a great asset for rural development, to comply with official legislation, which is, in most cases, focused on medium and large agroindustries, not allowing the legalization of small enterprises. In addition, the low labor qualification, as well as difficulties to acquire equipment and to introduce new technologies, ends up being a great issue to the development and growth of this sector in Brazil.

Brazil exporter of commodities and food importer

Brazil has an expressive number of micro, small and medium-scale agroindustries; however, it still needs to import food, despite exporting soy, maize, and meat, among others. The Brazilian food industry is mostly restricted to the main agricultural commodities, highlighting as: a) first producer and exporter of orange juice worldwide; b) the world's leading producer and exporter of sugar; (c) the world's largest meat exporter, although it is the second largest producer; (d) the world's second largest exporter of soybean oil, although it is the fourth largest producer of soybean oil; (e) the second world exporter of soluble coffee; and (f) the world's second largest exporter of processed foods (in volume), due mainly to exports of orange juice (Associação Brasileira das Indústrias da Alimentação, 2016).

In the article entitled *Brasil: fonte de alimentos para o planeta?* (*Brazil: source of food for the planet?*), Vieira et al. (2016, our translation) report that:

> [...] the Country has a world-renowned seed industry, in addition to machinery and agricultural inputs industries, processing units, especially meat, oil, juice and cotton industries capable of operating at global scale and contribute to change the national statistics that today places Brazil as a commodities exporter.

The predominance of this type of industry, preferably "commoditized", is extremely exposed to fluctuations in international markets, limiting possibilities of product differentiation and increased value added.

Embrapa, according to its annual Social Report, has been active in new products development and in the improvement of agroindustrial food processing to benefit the population. The impacts caused by technologies transferred to society are positive, ensuring food safety and the activity sustainability. In the last 5 years stood out projects that have worked with industries and agricultural family to

promote the advancement of knowledge of the most different opportunities of Brazilian agribusiness (Embrapa, 2017).

Final considerations

One of the greatest evils of humanity is hunger, which among other things is a result of the absence of effective food conservation and lack of access to food due to socioeconomic and political conditions, not necessarily due to production limitations. Based on public policies, many solutions can be implemented in food safety programs, and in the technical context, two key aspects need to be considered as a solution: reduction of losses and use of agroindustrial waste.

The frequent search for increased production is systematic; however, little is said about the large number of lost foodstuff. Undoubtedly, logistics is included, in particular the challenges of the cold chain, which need to be addressed. However, no less important are the actions that involve handling/processing of food. In the various production chains, failures occur in packaging systems, inadequate transport, lack of knowledge of the inherent characteristics of raw materials and, consequently, in the application of conservation measures, among others. It is up to the research to find solutions that improve the productive chain, being also necessary to take the existing knowledge and practices for meaningful answers. There is also the need for labor qualification. Many losses are not due to lack of technical information, but of the correct application by the teams.

With regard to agroindustrial waste, the research challenge becomes even greater, since new product lines and/or introduction of these lines must be created in existing lines; also, issues such as quality and quantity of waste, possible markets, collection system, and storage. Research must consider these aspects so that new solutions to waste use or full use of food are possible instead of simple discard them. Otherwise, the productive sector will not be involved or even be interested in this type of reuse.

It is paradoxical that Brazil is a power in food production and, at the same time, still deals with food insecurity. This situation tends to worsen with population growth and increasing scarcity. Research with industry and retail has the unique opportunity to work both in reducing losses along the production chain and in the waste utilization as a business opportunity and in reducing production costs.

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Chapter 3

Strengthening agricultural research

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Introduction

Concerned with meeting the dynamic demands of society in food production and in solving related issues, Embrapa constantly seeks to update its project portfolios and to train its research teams.

This chapter shows contributions from Embrapa towards target 9.5 – Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development. As a highlight of this goal stand out training, qualification and improvement of Embrapa's research framework, as well as the alignment of research projects with the demand of Brazilian society and the world.

For Embrapa to become competitive among international markets, investing in the elaboration of new technologies is fundamental, as well as in process optimization, new products, besides focusing on workforce training in face of the new industrial challenges. Investments in qualification and training of research workers are ongoing actions. Embrapa has several mechanisms to successfully achieve the increase in research, development and innovation.

With regard to qualification strategies of research workers, publications are made available with pre-established frequency for the accomplishment of postgraduate courses, short courses in distance education format and calls for the stimulation of external partnership and collaboration.

Embrapa has the Rede Embrapa de Conhecimento (Embrapa's Web of Knowledge), consisting of the Decentralized Units, Central Units, Labexs (Embrapa's laboratories abroad), besides other external partners of the public and private sectors. Labexs are located in several countries (the United States, Europe, China and South Korea) enable the constant scientific training and cooperation of its workers, aiming at the internationalization of Brazilian agricultural research.

Solutions

The Sistema de Inteligência Estratégica da Embrapa (Embrapa's Strategic Intelligence System – Agropensa) is a tool used to act in the capture and prospection of trends to identify possible futures; and in the mapping and support to the organization, integration and dissemination of database and agricultural information, thus allowing Brazilian agriculture to be prepared in the face of potential challenges and opportunities.

Regarding Embrapa's strategic management process, there is information needed to support the formulation of Research, Development & Innovation (RD&I). In performing these actions, the Agropensa System fosters the articulation of internal and external stakeholders, encouraging organizational and institutional partnerships. This dynamic enhances the generation of knowledge and the achievement of innovative solutions for Brazilian agriculture of the future (Embrapa, 2017b).

Considering the growing concern on the multidisciplinary role that agriculture will play increasingly in the future and its constant dependence on knowledge, technologies and innovation, Embrapa is prepared for this task (Embrapa, 2017a).

Research and development

Embrapa has its agenda focused on providing new knowledge. Much of this agenda is translated into products, processes and services for the agricultural sector. Embrapa carries out studies, actions and generation of qualified information that contribute directly to increase competitiveness and sustainability of agriculture. Its action can also be seen in the contribution it offers to the formulation and improvement of public policies.

Research programming

Research programming has been defined from the implementation of management models focused on obtaining effective results, which translate into changes and effective improvements in the reality of the beneficiaries of our products and services. Its management model promotes a systemic, integrated and transparent view of Embrapa's actions and supports the complete cycle of the management of research projects: planning, execution, follow-up, evaluation,

feedback and schedule for releasing financial resources. All employees and external users participating in research projects can access this information.

Portfolio

Portfolios are instruments of managerial support for the organization of related projects, according to thematic vision with the objective of directing, promoting and monitoring the achievement of the results in specific themes. Due to the strategic and national, regional and local relevance, the themes of the portfolios address the most different subjects, such as Agroindustrial Technologies for Adding Value to Products; Food, Nutrition and Health; Safe Food; Aqualculture; Strategic Management of Genetic Resources for Food, Agriculture and Bioindustry; Biomass Chemistry and Biotechnology; Ecologically-Based Production Systems; and Alcohol and Sugar for Energy.

R&D Arrays

Arrays are groups of convergent, complementary and synergistic projects organized to face priority challenges within a given theme, preferably based on the joint vision of more than one Embrapa Unit. Currently, there are 71 approved arrays that synergistically address topics such as: genetic improvement,sustainability and plant and animal production systems; citrus HLB and fruit flies; pests and toxins of stored grains; among others.

However, until January 2017, 34 arrays were approved. They will compose Embrapa's R&D actions. These projects refer to the production of food and innovative solutions for agroindustries.

Qualification of external agents

As a way of training agents of the production chains that EMBRAPA serves, a series of mechanisms are available to reach the different target audiences. In addition, television programs such as Field Day on TV at the national level and the South Land program at the regional level are available; radio program such as the Rural Prose; as well as Facebook and Youtube fan pages with videos demonstrating technologies, products and processes. In addition to these sites, EMBRAPA's broad catalog of products, processes, services, methodologies, agricultural practices and systems can be accessed on Embrapa's website (Embrapa, 2017c).

Recently, Embrapa has launched the Prosa Rural-Prosa Web application for the Android system, available on both Google store and Play Store, with two functions that can be used interchangeably, available for listening, downloading and sharing content. The first function has the collection of the Rural Prose produced since 2004, gathering more than 2 thousand radio programs from Embrapa on the various agricultural themes. Content can be selected by region, date, or subject criteria. The second function is Radio Embrapa ProsaWeb, which operates 24 hours a day with a selection of the program's collection every 20 minutes. During intervals, there is agricultural news, interviews, and weather forecast daily in the morning.

Nonetheless, through its 42 Units, Embrapa promotes qualification of the various types of multipliers in loco, in the most varied themes, through training for technicians and producers, in addition to undergraduation and postgraduation courses, among others.

Final considerations

Embrapa has various ways to make available knowledge in the form of research, innovation and diffusion of its technological solutions. The contributions are both in the sphere of strengthening research and innovation through internal training strategies of its technical staff, as well as qualification of agents representing the productive chains that the it meets. In addition, efforts are constantly being made to update research management models and their project portfolio to ensure that research topics are connected to the evolving world.

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Chapter 4

Innovation in agricultural research

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Introduction

Concerning target 9.b – Support domestic technology development, research and innovation in developing countries, including by a conducive policy environment for, inter alia, industrial diversification and value addition to commodities – Embrapa has promoted research and development activities to add value to products derived from the production chains it serves. Thus, it has encouraged the intelligent use of food and its byproducts generated during agroindustrial processes.

The stimulus occurs through food processing and the development of new products and processes from commodities and family farming (considering commodities grains, fruit purees, fruit pulp, meat, cotton, etc.) focusing on adding value, as well as promoting the use of byproducts.

Embrapa has been active in the development of new products and in improving agroindustrial processing of food for the population benefit. The impacts caused by the technologies transferred to society are positive, guaranteeing food safety and the activity sustainability. In the last 5 years stood out projects that worked with industries and family farming to promote knowledge advancement of the most different opportunities of Brazilian agribusiness (Embrapa, 2017b).

According to the Embrapa Social Report (Embrapa, 2016, 2017a), results developed enabled an increase in the productivity of family agribusiness in different regions of Brazil. As examples of research:

- New cultivars such as hybrid BRS Gigante Amarelo and BRS Sol do Cerrado show 285% higher productivity in relation to previously cultivated materials, as well as disease resistance. This has benefited farmers in

590 properties, generating around 5,000 direct jobs and 10,000 indirect jobs, in addition to producing approximately 120 million dollars[1] in the wholesale market (Embrapa, 2017a).

- The sweet potato cultivar BRS Amelia stands out for its texture and sweetness, with an average productivity 2.36 times higher than the average production in Brazil, as well as a reduction of 50% in post-harvest losses and increase in farmers' profits by up to 60% in average prices, generating an agricultural income of approximately 30 million dolarsfor approximately 40 thousand family farmers and traditional communities (Embrapa, 2017a).
- Apyrenic cultivars (seedlessness), such as BRS Clara, BRS Morena and the most recent BRS Vitória and BRS Isis, represent 70% of the total marketed table grapes, whose 9 kg box is exported for 16 Euro. Approximately more than 200 families of farmers use these new table grape cultivars in several regions of Brazil (Embrapa, 2016).

In 2003, Brazil took the lead in international beef trade. The importance of owning the largest commercial cattle herd in the world reflects the need to develop strategic research actions to provide technological solutions able to act facing the great sector challenges for the production and industrialization of this animal protein. Embrapa has been active in the development of programs of good agricultural practices in beef cattle in order to provide information that makes production systems more profitable and competitive, as well as guaranteeing the supply of safe food products from production systems (Embrapa, 2017b).

Dairy farming can be one of the potential agricultural activities. In Brazil, several propitious characteristics point to a positive projection in the coming years. However, the activity success depends on an efficient management for the total control of the production and availability of technologies for the sustainable development of this activity. Embrapa has been working mainly in the development of Research Network programs for dairy agricultural production systems in different regions of the country. In addition, through the Projeto Balde Cheio (Full Bucket Project), the Embrapa has worked with the industry to promote sustainable milk development in all aspects: technical, economic, social and environmental.

[1] Values related to December 30, 2016: US$ 1.00 corresponded to R$ 3.2585. (Taxa..., 2016).

Embrapa's technological solutions

The technological solutions benefit family farmers, in which application technologies were developed to manufacture these products, promoting social inclusion of small-scale farmers as well as benefiting large industries and commodities. Products, processes and machinery can use raw materials of plant or animal origin.

Agroforestry system Cambona 4

The principle of the agroforestry system is to plant yerba mate intercropped with native trees to rebuild the plant's natural habitat. The great advantage of Cambona 4 is its productivity two times higher than common herbs and for producing a soft drink, achieving a price 65% higher than the common yerba mate (Embrapa, 2011a).

Acai management technology

Acai palm (*Euterpe oleracea* Mart.) is a native plant of the Brazilian Amazon (Figures 1 and 2). The state of Pará is the main center of natural acai dispersion. This technology bases on the elimination of shrub and trees of low commercial value, and the open spaces are occupied by acai palms from seeds or transplanted in the vicinity, or enriched with the planting of other species of commercial interest, reconciling, in a rational and balanced way, environmental protection with economic yield. This palm is abundant in this region and produces food for the local populations, besides being the main raw material source for the palm oil agroindustry in Brazil. The adoption of the technology already reaches 59 thousand hectares and has been expanded, above all, in the states of Pará and Amapá. In 2016, its economic benefit to the region was approximately 34 million dollars (Embrapa, 2017b).

Cashew fiber hamburger and vegetal proteins

Cashew hamburger (Figure 3) is produced with cashew fiber, a byproduct discarded from the juice industrialization. This solution shows two alternatives, one for industrial production with textured soybean protein and one on a small scale, based on cowpea beans as protein, serving both the commodities market and family farming.

Photo: Ronaldo Rosa

Figure 1. Native acai palms.

Photo: Rafael Rocha

Figure 2. Acai bunch.

Bel potato for chips and straw potato production

The potato chips and straw potato industry involves hundreds of small and medium-sized enterprises in Brazil and faces enormous difficulty in obtaining

Photo: Ana Elisa Galvão Sidrim

Figure 3. Vegetable hamburger of cashew fiber.

good quality raw materials. The BRSIPR Bel potato cultivar (Figure 4) meets this need. It is mainly intended for cultivation in regions whose production is dedicated to the processing of potato chips (Figure 5) and straw potato, both in small and large industries (Embrapa, 2012b).

Photo: Paulo Lanzetta

Figure 4. BRSIPR Bel potato in natura.

Apple cider

Cider elaborated with a single variety ('Gala' or 'Fuji') (Figure 6) can be an alternative of diversification and use of discarded apples in the classification process. Elaborated by the Charmat process, based on natural fermented apple,

Photo: Paulo Lanzetta

Figure 5. BRSIPR Bel potato chips.

Photo: Viviane Zanella

Figure 6. Bottles of cider and apple.

it has good effervescence, pleasant fruity aroma, clear color with an intense and striking flavor of ripe fruit. It is a refreshing product of low alcohol content.

Arracacha cultivar Amarela de Senador Amaral

Arracacha is a product of high commercial value, being used by the food industry for baby food, but with low availability and difficulties in propagation, cultivation and disease. The cultivar Amarela de Senador Amaral (Figure 7) is more precocious and produces 25 tonnes per hectare, twice as much as traditional material. In addition, the research developed methodologies of cultural management and propagation that ensured superior quality to seedlings. As a result, Amarela de Senador Amaral occupied 70% of the crops, and the area planted in Brazil still grew 26.8% in 2007 since its launch in 1998 (Embrapa, 2009).

Dual purpose wheat 'BRS Tarumã'

The 'BRS Tarumã' wheat, introduced in 2005, has a dual purpose, allowing up to two grazing livestock (Figure 8) without damaging grain harvest, occupying, in

Photo: Leandro Santos Lobo

Figure 7. Fresh arracacha.

Photo: Renato Serena Fontaneli

Figure 8. Integrated crop-livestock-forest system: dual-purpose wheat cultivar BRS Tarumã.

2010, 10% of the wheat area for exclusive grain production in Rio Grande do Sul state. With the recommended management, the critical winter season obtained from 150 kg/ha to 300 kg/ha weight gain in precocious veal or from 1,200 kg to 2,500 kg milk/ha. To this income there is also the grain harvest, up to 4,500 kg/ha, with industrial quality similar to imported wheat. In addition, after harvest, the straw protects the soil from erosion and increases its fertility (Embrapa, 2012a).

Minifactories processing cashew nuts

The cashew nut minifactories (Figures 9 and 10) obtain the highest quality and proportion of whole and white almonds. The implementation of the minifactories system encourages production by small and medium producers, whose manufacturing modules are composed of a structure that can be adapted to the size and capacity of each unit (Embrapa, 2002).

Photo: Claudio Noroes

Figure 9. Cashew nut drying process in the minifactory.

Photo: Claudio Noroes

Figure 10. Selection of cashew nuts in the minifactory.

Processing of green coconut bark

The green coconut bark has an advantageous physical structure, providing high porosity, high potential of retention of humidity and favoring the physiological activity of the roots. It can be used as an ingredient for the formulation of agricultural substrates and organic compounds. The fiber (Figure 11) can be used as a raw material for handicrafts, for making pots and plates for planting, as a substitute for *xaxim*, for upholstery of vehicles and for bioblankets manufacture, which can be used to contain hillsides or degraded areas and in interior decoration (Embrapa, 2017b).

Photo: Claudio Noroes

Figure 11. Processing of green coconut shell for fiber and powder production.

Portable cotton small factory

The small factory and baler press developed for the production processing in the property can be used in the cultivation of organic and colorful cotton, niches of market not served by great cotton companies. The machinery enables the producers to add value to their production, marketing the fiber directly with the industry. In addition, it allows the producer to use the seeds for animal feed, which would not happen if the production were sold without the processing (Embrapa, 2002).

Hydrothermal treatment of Brazilian mango

This process was developed between Embrapa and public and private institutions, enabling since 1991 the export of fruit to several countries, whose objective is to kill

eggs and/or larvae of fruit flies in mangoes. This process led to an increase of 17.2% in mango exports. Only in 2015, exports of 471 tonnes of mango generated more than 47,000 jobs in its production and processing chain, with the states of Bahia and Pernambuco accounting for about 80% of total exports (Terao et al., 2014).

Adding value to sheep meat through manufacturing of sheep meat products

This technological solution refers to the processes of adding value to sheep meat of different categories (lamb, ram/ewe and discard sheep), through the development of meat products and convenience products. The processes involve two product lines: Premium (dry-cured hams – Figure 12, coppa – Figure 13, smoked bacon, light sausage,) and Low Cost (mortadella, sheep liver *pâté* with fine herbs, , hamburgers and bacon – oveicon – Figure 14) (Embrapa, 2015b).

Photo: Paulo Lanzetta

Figure 12. Dry-cured lamb ham.

Photo: Paulo Lanzetta

Figure 13. Lamb coppa.

Photo: Paulo Lanzetta

Figure 14. Lamb bacon: oveicon.

Innovation in the agroindustry of artisanal rennet cheese

Artisanal rennet cheese, widely consumed and produced in the Brazilian Northeast by a large portion of family farmers, has a technology that includes a production kit (Figure 15) and guidelines on Good Manufacturing Practices (GMP). The result is the standardization and a product with safety and quality for commercialization, benefiting this portion of producers (Embrapa, 2012b).

Photo: João B. C. Araújo

Figure 15. Kit for artisanal production of rennet cheese.

Canned tilapia fillet (species)

Tilapia fillet (species) has an expanding market, mainly in self-service restaurants, and has a reasonable distribution in supermarket chains. However, there are not many processed product options, such as canned tilapia products (Figure 16). In the market, there are only tuna and sardines canned products. This process increases the shelf life of a perishable product and, consequently, the commercialization time, being an indication for the fish processing industry.

The differential advantage is the added value of a product traded traditionally fresh (Embrapa, 2011b).

Photo: Tomas May

Figure 16. Canned tilapia fillet.

Portable slaughterhouse for swine

The prefabricated portable modular slaughterhouse technology (Figures 17 to 21), for a single location (stationary) or itinerant (transportable by road wagons), is aimed for solving one of the major bottlenecks in livestock production in small scale, which is the slaughter stage. All the equipment of a fixed slaughterhouse is adapted to a road wagon or refrigerated container, making possible a structure that can be shared among different users and regions and quickly built. Its implementation is subject to approval by the official inspection agencies of animal products and environmental licensing (Embrapa, 2015a).

Photo: Lucas Scherer Cardoso

Figure 17. External view of portable slaughterhouse for swine.

Photo: Lucas Scherer Cardoso

Figure 18. Slaughter test: bleeding.

Photo: Lucas Scherer Cardoso

Figure 19. Slaughter test: hair removal.

Photo: Lucas Scherer Cardoso

Figure 20. Slaughter test: carcass opening.

Photo: Engmaq

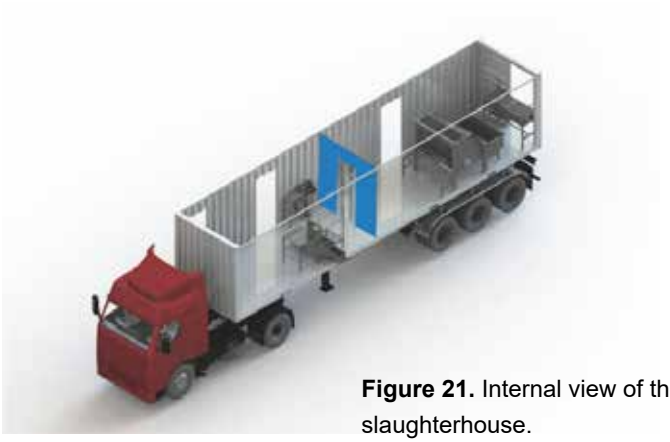

Figure 21. Internal view of the portable swine slaughterhouse.

Final considerations

In order to deliver innovative products, processes, systems and machinery that contribute to the reduction of food losses and waste, as well as the presentation of resilient and sustainable structures, Embrapa is engaged and has been working systematically to achieve these goals. Therefore, it has stimulated the development of projects in these areas.

Because of this stimulus to research, this chapter showed some technologies with great potential for innovation, with the elaboration of resilient structures, processes that take care of the environment and the sustainability of those spaces where people and companies have adopted them.

However, despite all the efforts and products, there is still a need to advance much more, increasing industrial automation processes, developing safe packaging, reducing production costs, with sustainability and environmental care.

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Chapter 5

Solutions and challenges

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Solutions

Brazil is a great power in food production: fruits and vegetables, grains, meats and milk, cotton, sugarcane and many others. Its industrial diversification reaches home agroindustries, artisan family agroindustries and small family agroindustries, which show significant growth. In addition, Brazil is one of the largest exporters of commodities, in which Embrapa had a significant participation in the development of this sector so important in the national economy. In addition, Embrapa constantly contributes to qualification and training of the various factors that make up this agroindustrial complex.

Despite this growth of Brazilian industry in recent years, losses and wastes in Brazil are still large, despite being a commodity exporter. Losses can occur from production to post-harvest, storage, consumption and industrialization. The processing industry has the lowest rates of waste, since it normally takes full advantage of the received raw materials. Embrapa has developed targeted research to generate technologies focused on the whole use of raw materials.

However, despite the growth in food agroindustrialization in Brazil, there is several difficulties, such as lack of stakeholders' organization, problems in enterprises legalization, lack of access to production and low capacity, common among small Brazilian food producers.

Embrapa maintains several means of qualification of its employees in research, as well as several mechanisms to achieve successfully incremental research, development and innovation. Agropensa is one example, whose system designs the future of agricultural research, as well as the portfolios of areas of research, which allow Embrapa's research workers to develop projects based on market

trends. In addition, several TV, radio, YouTube and social networks programs aim at informing and training the producers in the various technological solutions.

Despite Embrapa's performance in Brazilian agricultural research, there is a need to increase research investment in Brazil to ensure the continuity of the virtuous cycle of innovation in the agricultural sector. It is imperative to encourage more intense engagement of the private sector in agricultural R&D activities. Increasing the contributions of national treasury resources is, of course, strategic action, which must be pursued. Public-private partnerships in agricultural research, focusing on high impact innovations, are interesting ways to ensure a significant part of the innovation flow. To broaden and consolidate the set of RD&I actions – public, public-private, private –, in accordance with well-designed goals and objectives, is vital to guarantee the sustainability and competitiveness of Brazilian agricultural and related productive chains in the coming decades (Martha Júnior et al., 2016).

Embrapa presents, as results of its research projects, products that can be appropriated by agroindustries, both family and commodities, focusing on the development of new products and the improvement of the agroindustrial food processing for the population benefit. There are several solutions, from products developed based on plant raw materials, as well as from animal origin, and processes and machinery. Thus, the solution can go from a cultivar developed for industrial purposes, or a simple equipment to break an almond shell, or a portable meat industrialization unit approved to obtain legal records of production and commercialization.

Future challenges and possibilities

In spite of the various technological solutions developed by Embrapa, there is a need for a look at the future and work towards the development of new products and technologies that meet the demands of the new generations.

In the "bioeconomy" era, the possibilities of diversifying traditional agricultural – biopharmaceuticals, bio-inputs and bioproducts – make their products substantially more valuable and smaller exposure to the price cycles of agricultural commodities. It is possible that conditions that are more robust will emerge for a greater productive inclusion and for the sustained income expansion in the field, as greater possibilities for product differentiation and market expansion are established (Martha Júnior et al., 2016).

Among the potential future to be explored, there are some quite expressive facts in the agribusiness and food area, being necessary:

- The development of automation and precision agriculture strategies for value added to agricultural products, including the development and adaptation of sensors and actuators for automated systems, both in the production and processing of agricultural products.
- The elaboration of strategies for the spatial evaluation of agricultural property, determining the most suitable sites for generating differentiated products, including the development of sensors, techniques for characterization and similar for product and process traceability, quality and safety improvement, contributing to environmental, social and food safety certification.
- The production of high-efficiency, long-release agricultural inputs and ingredients for target compounds that can add value to the agricultural chain, such as nanofertilizers, nanopharmaceuticals, additives (aroma, nutraceuticals, pharmaceuticals, chemicals, semiochemicals, etc.) that allow for greater efficiency in its functionality.
- Development of production processes, reuse and optimization of energy sources from the perspective of sustainable use of renewable raw materials.
- The prospection of new materials to improve agroindustrial processes, such as fertilizer application, controlled and localized chemical release, in water decontamination, sanity, nutrition and reproduction, among others.
- The generation of new materials based on agricultural products and waste from manufacturing processes for non-food uses, including the search for new components and constituents of interest to different industrial sectors such as the chemical, plastic, automobile, paper, textile and pharmaceutical industries, as well as the development of new polymers, substances and biomolecules synthesized on biotechnology platforms, including synthetic biology, gene-editing tools and others.
- Prospection of bioaccessibility, bioavailability and in vitro and in vivo efficacy of compounds of interest, as well as preclinical and clinical evaluations to substantiate allegations of food functionality.

- The development of food processing techniques to obtain new industrialized products through the Food Design concept, such as edible thin films, functional foods, fortified, reduced or free of sugar, sodium and trans fat, for specific audiences (athletes, seniors, children and others), including design for animal nutrition.
- The establishment of research focused on quality and value added in strategies of productive arrangements of small and medium producers, including strategies for agricultural family evolution of high profitability family enterprises.
- The development of added-value technologies to byproducts, waste and effluents from different chains.

Trends

Considering the consumer's point of view, some trends are:

- Teas and juices: specifically for the beverage market, emphasizing natural products (pure, whole), nutritious (rich in vitamins, minerals, fibers), functional (with good health-enhancing properties – "superfruits", "superfoods", "pre and probiotic), with caloric reduction (lower sugar or sugar-free contents), for specific publics (pregnant women, elderly, athletes) or mood-products (to cheer up, encourage, relax, energetic).
- Considering the sustainability issue, there will be a trend in the search for beverages with reduced consumption of plastic material in packaging and juices with carbon footprint reduction, with recycled and recyclable packaging.
- In addition to the "good health" concept, large companies are already committed to reducing sugar by up to 25% in the coming years. There will be a 10% increase in natural beverage consumption, with reduction of soft drinks and artificial juices, in addition to the increase of fiber intake, prebiotics and probiotics.
- Consumers will seek food directly linked to their specific good health needs, aimed at reducing cholesterol, improvements in gastrointestinal transit, specific vitamins, among others.

However, these foods must be sensorially pleasant, convenient and practical and provide information about their properties to consumers.

In relation to animal product, trends converge towards: (a) consumers willing to pay more for products that meet the needs of animals; b) animals raised with comfort and well-being as they tend to become less sick; c) imposition of large groups on suppliers to adhere to animal welfare practices.

Finally, there is a need to maintain public policies, such as the Food Acquisition Program (FAP) and the Brazil's School Feeding Program (Pnae), which promote the insertion and consumption of regional foods and the adoption of traditional foods by young people, aiming at the creation of a traditional and regional sensorial memory, with the rescue of cultural, ethnic food, among others, developed still in the infant-juvenile age. Allied to these factors, there is a need for producers' qualification to meet the quality standards of the products, according to the legislation of the inspection agencies.

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MINISTRY OF
AGRICULTURE, LIVESTOCK
AND FOOD SUPPLY

ISBN 978-65-86056-21-1

CGPE 016712