

EXPERIENCES OF THE CUBAN CLEANER PRODUCTION FOCAL POINT FOR AGRO-INDUSTRY

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ABSTRACT

This chapter presents an overview of the experience gained in the project "Establishment of the National Network of Cleaner Production in Cuba", which was performed in cooperation with the United Nations Industrial Development Organization. It includes the major innovations developed by companies involved in this project, the activities carried out to disseminate information and national awards won as results of the implementation of Cleaner Production Strategy in the agro/food sector. The implementation of this strategy has addressed the new challenges implied by global competition with the reduction in water consumption by 684,508 m³, consumption of electricity by 12,886 MWh, consumption of energy carriers by 218,241.26 litres, the CO₂ emissions to the atmosphere by 3,148 t and the pollution load of industrial effluents by 5,055 t of Chemical Oxygen Demand for an economic effect of 8,567,667 convertible pesos (CUC), 4,174,714 Cuban pesos (CUP) and increased exports of 476,079 USD. This strategy demonstrates specific actions and goals in terms of production, emphasizing the need for social participation.

1. INTRODUCTION

The National Network of Cleaner Production of Cuba (RNPML) was established by the United Nations Industrial Development Organization (UNIDO) in May of 2001 with financial support from the government of Austria. It began with three focal points located in the Research Institute for the Food Industry (IIIA), the Research Institute for Sugar Cane (ICIDCA) and the Center of Information and Management of Environmental Education (CIGEA-AMA), belonging to the ministries of the Food Industry, the Sugar Industry and Science, Technology and Environment, respectively. Two additional focal points located at Research Institute on Tropical Fruit (IIFT) and the Center for Genetic Engineering and Biotechnology (CIGB) were incorporated in the middle of 2003.

The focal points in each sector of the national economy belonging to the RNPML offer technical and managerial assistance services, CP quickly and in-depth plant assessment, training, assessment for projects to promote investment, transfer of environmentally sound technologies, responses to requests from users through the information centres and support of synergy with the multilateral environmental protocols, through dialogue between industry and government.

The fundamental activity of the Cleaner Production (CP) focal point at IIFT initially focused on supporting the technical aspects of citrus and tropical fruit processing. Based on the economic performance, environmental and social progress achieved in the citrus sector, these activities were incorporated in other sectors such as the livestock, pigs, poultry, coffee and tobacco industries. The CP focal point has maintained these activities until the present, with the support of UNIDO, the financial contributions of the companies themselves and the existence of a national project called "Implementation of Cleaner Production for sustainability of the agro-industry sector", which is financed by the Program for the Preservation of Natural Resources of the Ministry of Agriculture of Cuba (MINAGRI).

This strategy uses specific production actions and goals, emphasizing the need for social participation, ethical both from the point of view and in the methodological aspects. Great importance is attached to transparency and to the adoption of effectiveness in environmental management because effectiveness implies systematic changes in planning, implementation and evaluation of the productive activities.

By virtue of the importance of the topics treated, the quality of the work performed and the innovations developed, this initiative will be of great value

to analysts and decision-makers interested in developing a healthy environment. The information presented is useful for both present-day issues and the challenges of the future.

2. THE CUBAN FRUIT INDUSTRY

The fruit sector is currently under the jurisdiction of the Fruit Group Company (GEF), which operates as a holding company belonging to the Ministry of Agriculture. It is composed of five agro-industry companies, involved in processing citrus and other fruits. The GEF is implementing different actions as part of the national strategy, seeking to give a new impulse to the production of citrus fruit, to supply different destinations and to cover, gradually, the demand for these products in the island.

The citrus program works to revitalize this crop, which has suffered due to the effects of the plague Huanglongbing (HLB), more commonly known as “yellow dragon”. The area of citrus in active cultivation comprises 26,000 hectares, of which 90% have been exploited for over 30 years. This has been coupled with the need to create a nursery infrastructure to ensure the production of more than two million plants per year, to ensure an average of 3,000 hectares planted each year. Moreover, the citrus program applies the novel method of mixed cropping to the strategy of developing fruit. Cooperatives involved in the fruit industry in Cuba also grouped 2,334 farmers within 31,000 hectares designed for the production of mango, guava, avocado, papaya, pineapple and other species and 60 small processing industries (FAO, 2014).

Fruit processing lines were installed in the citrus industries to diversify production and increase use of infrastructure throughout the year. This strategy, in addition to reducing investment in new industries, uses the current capacity of steam, cooling and storage, among others, increasing work force stability.

3. CLEANER PRODUCTION STRATEGY IN THE AGRO-INDUSTRIAL SECTOR

The citrus and fruit processing lines have benefited from the practical implementation of the Cleaner Production methodology and completed their

respective “CP in-plant assessment”. This has allowed them to achieve significant results in their management and has technically prepared them to achieve more efficient production. This preventative approach has allowed them to raise industrial performance, reduce production costs and minimize the environmental impacts of activity and the risks to human beings. In addition, it has minimized the consumption of water and energy as well as waste generation during the production processes (ONUDI, 2007).

3.1. Technological Innovation

A common aspect of the citrus and fruit processing industries participating in the Cleaner Production project has been the development of technological innovation. This is due to limitations on equipment acquisition, the opening of an increasingly globalized market since the disappearance of the socialist bloc and the imposition of laws for environment conservation, quality, health and safety, among others.

The development of innovation enables the establishment of strategic alliances between industries and institutions of science and technology. Some sustainable solutions were implemented thanks to alliances among technicians, specialists and scientists. Innovation has been achieved due to many factors, including the implementation of improved production processes, product innovations, innovation management and organization of the market. It is about not only doing different things but also doing the same things differently.

It is important to acknowledge that the leaders of promoting innovation have been the CP multidisciplinary teams, which were created in the companies involved with support from the Research Institute on Tropical Fruit. These teams demonstrated that was an optimal working solution, instilling an organizational culture for innovation to be assimilated by partners, customers and suppliers.

The main innovations implemented in industrial enterprises in the fruit sector follow.

3.1.1. Rehabilitation of the Fruit Processing Line in the Contramaestre Industry

The fruit processing line was operated manually, which caused losses of 11.2% in the production of mango pulp, 6.5% in guava pulp and 7.6% in tomato puree. Equipment was set up to feed the raw material, as well as a

roller table for fruit selection and a polishing machine for brushing and washing fruits. This enabled the automation of the process and the humanization of the task.

To reduce water consumption, water pressure systems and a mechanism for filtering and disposal of wastewater were installed, allowing reintegration of water into the process or routing it to the treatment plant. It is important to note that these facilities were constructed of machines from other industries that were not working. Moreover, the fruit processing line had only two concentrators for cooking mango pulp, reducing usage to 50% of the installed capacity. The Gen-Wieg and evaporator on the citrus line was coupled to the fruit line in order to establish a continuous flow, after certain adjustments to enhance productivity

With the implementation of 16 CP options, the production of mango pulp was increased by 266 t, the guava pulp by 135.5 t and the tomato puree increased 5.81 times, as well as the availability of deals on commercial networks - both national and tourism. The income earned by the production of pulp was 848,027.38 CUP and 16,250 CUC (Cabrera, 2012). In addition, water consumption was reduced by 18,401.21 m³, fuel oil by 7,785.94 litres and electrical energy by 44.57 MW/year. The concentration of pollutants was reduced by 54.1% of the Chemical Oxygen Demand, and additionally CO₂ emissions to the atmosphere were decreased by 84 t (Cabrera, 2012). The stability of the work force also increased by 95%, due to production diversification. Table 1 shows the increase in productive capacity, production and yield of the fruit processing line.

Table 1. Comparison of productive capacity, production and yield of the fruit processing line

	Before CP (2008)	After CP (2011)
Processing fruit (t)		
Mango	323,811	1,064,766
Guava	7,200	1,081,726
Pulp Production (t)		
Mango	141,934	519,600
Guava	4,000	10,000
Yield (t of fruit/t of pulp)		
Mango	2,28	2,05
Guava	2,28	1,69

3.1.2. Use of the Fruit Processing Line for Tomato Pulp Production

To use the fruit processing line during the tomato season, existing equipment of the citrus oil emulsion line was placed into transport tomato to the depulper and established a continuous flow. The income earned by the increase in the total production was 891,026.9 Cuban Pesos/year and savings in water consumption went from 15.75 m³/t product to 9.5 m³/t product (Conde and Morales, 2010).

3.1.3. Construction and Installation of a Machine for Fruit Cream Filling

Previously, the cream filling was done manually, which restricts the productive capacity of the mango and guava creams line. To change this, a semi-automatic machine was designed, built and installed. The use of the filling machine reduced the time needed to empty the concentrators and enabled faster cleaning. This saved water and resources for the cleaning process. The water saving for this item was 77.1m³/year, and the income was 97,560 CUP (Cabrera, 2012) due to the increase in the production of creams. Table 2 shows the increase in the cream production, daily and annually.

Table 2. Increase in production of fruit cream

	Before CP		After CP	
	Production u/day	Production u/year	Production u/day	Production u/year
Mango cream (500 g)	800	12,000	2,000	30,000
Guava cream (500 g)	800	1,600	2,000	4,000

3.1.4 Re-adaptation of the Fruit Processing Line in the “Ceballos Citrus Enterprise”

Grapefruit juice is lost during the production of sweet peeled grapefruit, which are produced outside of the harvest season. It was decided to produce the sweet peeled grapefruit in the fruit processing line, as it is not otherwise used during this time. The grapefruit juice production was increased by 36 t for an economic impact of 23,400 CUC (Conde and Morales, 2010).

3.1.5. Rehabilitation of the Citrus Processing Line for the Development of Concentrated and Aseptic Frozen Pineapple Natural Juices

A horizontal press was added to the existing citrus processing line, avoiding an investment of 80,000 Euros (the price of the press at international market). It allowed processing between 8 and 10 t/h of pineapple fruit and

production of 298 t of Frozen Concentrated Juice at 60Bx with an economic impact of 402,300 CUC (Vargas and Conde, 2010).

3.1.6. Guava Pulp Washing in “Heroes de Girón Enterprise”

The guava processing line has an installed capacity of 4 tons per hour with yields of 1.7 t guava / t pulp. It was recommended to use the existing equipment to reprocess the waste pulp and to wash the seeds while adding water. The new pulp obtained was mixed with the first screening pulp, and the combination was sent to the balance tank to feed the pasteurizer. The reduction in solid waste was 28% and profits increased by 60% (Fernandez, 2010). After the implementation of the CP option the production increased by 25%, with savings of 445.3 USD/t of pulp. Table 3 shows the increase of efficiency of guava pulp production.

Table 3. Reduction of yield, cost and energy consumption in the guava pulp line

	Yield	Costs	Energy consumption
	t of pulp/ t of fruit	Cuban Pesos	kWh/t
Before CP	1.70	3,009	58.07
After CP	1.29	2,563.50	56.17

3.1.7. Modernization of Drying Technology in “America Latina Enterprise”

The installation of solar dehydration technology in small industries constitutes a feasible solution because the country has this renewable energy source. It has a strong impact on the reduction of costs by replacing of fossil fuels and reducing global warming. Additionally, it provides value added to the agricultural product, contributes to the local development with generation of new products, income and jobs for the members of the cooperative and the incorporation of women in the production.

The solar-drying technology of the CONA SOLAR S. A. firm was brought in to improve the energy efficiency in companies that dried medicinal herbs. It allowed the replacement of 122MWh per year using an area of 60 m² of thermal panels with a power of 720 W/m². It improved the energy efficiency of 14 MWh of green product to 1.8 MWh per year and reduced emission of CO₂ to the atmosphere equivalent to 143 tons annually, corresponding to \$1,430 USD in carbon credits (Moya et al., 2011)

From the social point of view, the availability of a technology with a controlled atmosphere, where the worker would not be exposed to the heat and smells of plants during handling, improved the working environment. Moreover, with the use of humidity and temperature controllers, the workers do not have to manipulate the chambers to check the quality of products.

3.1.8. Installation Tunnel Dryer Solar Technology

In the community of Cooperative “Oscar Lucero”, a solar tunnel dryer was installed with a processing capacity of 30 tons of fresh fruit to be converted to approximately 6 tons of dried food products. This improved the economic conditions with a net income of 36,000 CUP, reduced the fruit losses due to lack of processing and enabled the employment of 10 women, which allowed improvements in the living conditions of families (Moya et al., 2011).

3.1.9. Innovation Bag

Technological innovation has been a successful mark of the CP in Cuban industry. To collect the main innovations an “innovation bag” was developed, in digital format, with a permanent update of costs, materials, places where were implemented, impacts on the reduction of the resources and authors of innovations. This aimed to increase the implementation speed of successful experiences.

3.2. Capacitation

The training, in addition to being designed to improve the productivity of the organization, has important social effects. On the one hand, the knowledge, skills and abilities acquired by each person allow critical thinking about how to produce goods and provide services to promote environmental improvements under current technological and economic limitations. On the other hand, it is an effective form of workers’ protection because it provides adequate preparation to cover a job internally or to be promoted.

The training program developed by the Focal Point of Cleaner Production, in collaboration with the National Network of Cuba, was primarily aimed at staff and officials of agribusiness relying on the commitment of corporate management. One feature of these programs is that they were developed in the industries and the activities were combined with practices through assessments of plants. One aspect that has contributed to improve results was the

presentation of final results of the “CP in plan assessment” to managers of the company, to seek solutions.

In addition to promoting internal courses for specific areas of production programs, subjects such as time management, conducting meetings, analysis and decision making were taught (Abreu et al., 2011). A positive experience gained by the project is that participants have become the “managers of the future” of the companies and could occupy new features quickly and effectively. Currently, the top management of the citrus industrial enterprises has been qualified and trained in the cleaner production program.

During the development of this project, it was shown that the companies in which greater efforts were made in the training of staff were the ones that benefited most in the market. The investment in training resulted in benefits for both the person who was trained as well as for the company. Furthermore, promotions, transfers and training activities were important factors in motivation and retention of staff. The training avoids obsolescence of knowledge on the staff, which generally occurs among the older employees if they have not been retrained.

The UNIDO also took into account the initial preparation of the coordinators of the Focal Points of National Cleaner Production Network, at its headquarters in Vienna. The other sources of knowledge were the regional and annual meetings of the Latin-American Network (RLAPML), the round tables of the National Network, as well as events and workshops that allowed extension of the spectrum of knowledge on different approaches. These workshops were on such topics as “Closing the loops”, “Life Cycle Assessment”, “Chemical Leasing”, and “Mechanisms of Clean Development”, which offered integral solutions in cleaner production to the industries. Additionally, websites such as the platform of Knowledge Management CP Latin Net, (<http://www.cp-latin-unido.net>) with important information about events, projects, manuals, trainings, experiences of successful cases of the National Centers of Cleaner Production (CNPML) and scientific documents were used.

3.2.1. Course of “Engineering in Cleaner Production”

The course, “Engineering in Cleaner Production” had a great impact during the development of this project, with the participation of other sectors of agribusiness such as tobacco, coffee, livestock and poultry. Currently, the 5th edition materials contain 33 final papers for 80% effectiveness and 105 identified solutions (Abreu et al., 2011). It should be noticed that the development of these theses was not only a contribution to the professional

development of participants, but also from a business point of view, they are strategic planning documents to identify sustainable actions for productive performance.

Among the topics covered, there were the studies to ensure water reuse, integrated waste management, agricultural soil management, irrigation systems, steam generations, water treatment plants, pumping stations, management of chemicals and pesticides in the crops, diversification of fruit processing, innovation in packaging lines, as well as the application of this strategy to new investments in solar dryer technology. The theme of Cleaner Production in business management and quality system standardization were also included.

The Manual of Cleaner Production for the citrus industry sector (Prevez and Osuna, 2007) is currently used as a textbook for the course “Engineering in Cleaner Production”, as it provides a logical methodology for CP in plant assessment. This methodology proposes tools for savings calculation, when conventional means of measurement are not available. It also offers experiences on the introduction of effective economic improvements and their application in planning the decision-making process.

3.3. Workshops

The motivation of the employees to participate in congresses, meetings and seminars was another achieved result. The organization of the theoretical and practical workshops allowed the participants to have a working methodology to evaluate the CP options identified from technical, economic and environmental points of view.

As a good example to demonstrate the effectiveness of the CP workshops, we cite the Second National Workshop of Environment by the citrus processing industries. It was shown, using statistical information from the same companies that environmental impacts were caused by losses in the production processes. The possibility to achieve a profit of approximately five million USD via the application of Cleaner Production strategy and techniques was also demonstrated. As a result, the commitment and support of the majority of the sector was achieved for the approval of the project, as it was demonstrated that implementation would allow increases in productivity, achieve better indicators of efficiency, make use of the flexibility of the facilities and especially use existing valuable human capital efficiently.

The dynamics developed in the formation and motivation of technicians, specialists and scientists, as well as the support of the companies and the Fruit Enterprise Group, have allowed the annual permanence of the National Workshops on Environment and Cleaner Production as a way of sharing the experiences and achievements, as well as recognizing the companies and individuals who have contributed to the development of this strategy. It is also a convenient time for the defence of final papers from the “Engineering in CP” course. Every year, a different company assumes the responsibility of organizing the annual workshops, surprising their collaborators and guests with the workshops’ high quality.

Among the other important results of the training activity are the following:

- Recognition by the Ministry of Higher Education for the course, “Engineering in Cleaner Production”, developed by the Focal Point, for all productive sectors.
- Cooperation in expanding the knowledge of the Cuban population on CP themes, through the course “Environmental Protection and Cleaner Production” in the Cuban television program “University for All”.
- Support of the identification of specialists among students of the Polytechnic Institute José Antonio Echeverría (CUJAE) and the University of Santiago de Cuba studying to reach the grade of Chemical Engineer.
- Support of the students in post-graduation programs in the centres of the Ministry of Higher Education and Research Institutes. As a result, 5 theses for master’s degrees and two doctorates have been defended on the CP subject.

Cuba currently has six Cleaner Production international trainers certified by UNIDO. In the fruit sector, there are two international trainers and seven national trainers.

3.4. Request Information

There has been active communication with the various sectors of agribusiness, providing quick answers and recommendations to problems. 40% of answered concerns corresponded to the citrus industry, 8% to the fruit

sector, 12% to various other crops, 14% to tobacco, 5% in the coffee sector and 22% for livestock. The main technical aspects covered were: waste management, chemical and hazardous wastes, environmental laws, environmental monitoring systems, procedures to become recognized by the National Environmental Award, implementation of the Management System and bonuses for purchasing environmentally sound technologies or introducing clean technologies.

3.5. Information Dissemination

The dissemination of achievements was also another activity that the focal point has developed, through interviews and promotions in radio, television and press as well as informative materials such as brochures, posters, calendars, newsletters, web pages, sweatshirts and CDs, in conferences and seminars. The persons who are involved in a CP project need to know the progress, strategies and techniques that have been successful, those which brought some success or have failed, and pay attention to the individual activities that have reported benefits in the company.

Furthermore, the Focal Point IIFT prepared a TV program about innovations and the successful results of the Cleaner Production implementation in the citrus industrial sector, which was presented by the informative program on Cuban television “De Sol a Sol” directed by AGRINFOR, part of the Ministry of Agriculture.

Informative activities have not been limited to the actions reported above. Some articles about successful and sustainable results are available in the proceedings of international conventions on the Environment and Sustainable Development; CITRIFRUT, CNIC Chemical Engineering, and Journals of Chemical Engineering. Articles were also published in the electronic newsletter NOTICITRIFRUT, and the web pages of UNIDO and the CP Latin American Network.

This information dissemination has also been completed through presentations by CP promoters from different industrial companies at national and international events, such as the TROPICO Convention 2004, 2009 and 2012, the V, VI and VII International Convention on Environment and Sustainable Development, and the CP Roundtables organized by the National Network, among others.

3.6. Advising on Environmental Policies

The role played by the focal point IIFT as advisor of the environmental policies has been highlighted for several reasons. First, it has helped to identify the principles in environmental policies of each industry during CP assessments to establish the Environmental Management System. Furthermore, based on the knowledge achieved in the implementation of Cleaner Production, it contributed to the introduction of the concept in the new Environmental and Sectorial Strategy of Agricultural Ministry, where it appears explicitly (CITMA-CIGEA, 2004).

Additionally, the focal point fulfilled the following goals:

- Collaboration in the development of the paper “Cleaner Production in policies and practices in Cuba”, which describes and analyses the environmental regulatory framework and the insertion of the Cleaner Production strategy in the industrial sector (CITMA-CIGEA, 2004).
- Collaboration in the design of the current industrial policy in the country.
- Membership in the national group for implementation of the “National Plan for the introduction of the Cleaner Production and Sustainable Consumption in the environmental management”.
- Contribution to the incorporation of CP data in the official statistical information and Environmental Investments since 2004 and in the annual official reports on the Cuban Environmental Situation.
- Contribution to the synergy of CP strategy with programs and projects, which support the state environmental management, oriented to the national implementation of Multilateral Environmental Protocols and initiatives.

3.7. The CP As a Tool for Obtaining the National Environment Award and Certifications of Quality

The focal point provides a great support for the preparation by companies of the eligibility forms for the National Award. As a result, the “Ceballos citrus enterprise”, in the year 2003 and the “Contramaestre enterprise”, in 2005, were acknowledged with the National Environment Award granted by the Ministry of Science, Technology and Environment in Cuba.

An important driving force for the motivation of companies and their workers is achieving the prize awarded by the Ministry of Agriculture of Cuba for the most relevant work in sustainable production proposals. The Agribusiness sector currently holds three of these prizes: MINAGRI AWARD 2004, 2005 and 2009.

Another rewarding stimulus for technicians, workers and specialists is the awards for active participation in the *Forum of Science and Technique*, a demonstration of the economic solutions that contribute the environment and social well-being. During the XV Forum of Science and Technique, four works were presented in the fruit industrial sector, three of which were assessed as relevant at municipal and provincial level, and one of them achieved a mention at national level.

The quality certifications supported by international agencies constitute recognition to the companies and are, in turn, a commitment to achieve excellence and to maintain it as a reliable institution. All of the citrus industries maintain the ISO 9000:2008 quality certification for exports of conventional and organic production in different markets. The Ceballos citrus enterprise has certified their Management system for occupational safety and health in correspondence with the ISO 9001:2008 and NC – 18001:2005 standards and certified their HACCP system in correspondence with the NC-136:2007 standard.

Other awards include the following:

- *The Award of the Youth Technical Brigades (BTJ)*: Presented to the paper: “CP: Ideas of sustainability for the fruit industrial sector”, which was evaluated as relevant and was awarded with the Provincial prize and the National Award in the year 2010.
- *The National Award for Technological Innovation, 2010*: The facility “Heroes de Girón” won the award for technological innovation in the year 2010, as a result of the presentation of sustainable initiatives in the packaging line of fruit processing.
- *The UNIDO Award*: Presented to "Ceballos citrus enterprise", as the first Cuban company who successfully implemented the Cleaner Production methodology in Cuba.

FOUR LESSONS LEARNED

The implementation of the CP project in the agribusiness sector has demonstrated that in the current conditions of the country it is possible, feasible and beneficial to promote projects of this nature to increase competitiveness and improve the performance of industries and mini-industries.

Linking industrial enterprises with scientific institutions, in the implementation of such projects, is helpful to achieve continuous improvements in business performance and development of the science.

The active participation of an international organization within the project allows constant updates on global issues.

A project of this nature motivates the fields of science, production and services to find ways to sustainable development for economic growth in a coordinated manner.

The structure of these projects leads to better technical, technological and innovative development inside the industrial systems and makes the most efficient introduction and development of new technologies possible, reducing polluting in the industrial sector.

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