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RECP Experiences

UNITED NATIONS
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United Nations Environment Programme

RECP Experiences at three quinoa processing enterprises

The efficient and environmentally sound use of materials, energy and water - coupled with the minimization of waste and emissions - makes good business sense. Resource Efficient and Cleaner Production (RECP) is a way to achieve this in a holistic and systematic manner. RECP covers the application of preventive management strategies that increase the productive use of natural resources, minimize generation of waste and emissions, and foster safe and responsible production. Benefits are eminent in many enterprises, regardless of sector, location or size, as demonstrated by the experiences of three quinoa enterprises [IRUPANA, AVSA and ANAPQUI**].**

Achievements at a Glance

In this case study we analyze the effect of a cleaner production (CP) technological innovation on three quinoa processing companies. In order to establish the context of the study, it has to be said that quinoa is a unique grain in the world because of its excellent nutritional characteristics. It has an important content of high-quality proteins, a perfect balance of amino acids and it does not contain gluten. Due to these characteristics, quinoa is a 'complete' food and in several senses unbeatable, in addition to the fact that it is highly valued by international markets. For all these reasons, quinoa was declared to be the Perfect Food for Humanity by UNESCO.

In spite of the exceptional characteristics of this grain, the world seems to have discovered it only recently, which is why it has been called "the top secret super food". In recent years, world quinoa demand has risen significantly, something which is unprecedented and has been caused by three fundamental reasons which are: (1) the increasing demand for grains with no gluten content (at present 0.4% of the world population have celiac disease[1]); (2) the accelerated growth in demand of high-quality organic products together with the increase in the fair trade products market; and (3) food efficiency programs which are being adopted by several countries with the support of the Food and Agriculture Organization of the United Nations (FAO).

Nonetheless, the major machinery and equipment manufacturers of the world did not produce custom technology for quinoa processing activity, and therefore this unique segment remained unattended. This arises from the fact that quinoa production is quite small in comparison to other grains. As a result, there are not many companies in the world dedicated to quinoa processing, and the market for specific technology for this sector is comparatively reduced. It is most likely that the major technology manufacturers of the United States, Europe and Japan were not interested in investing R&D resources in a sector constituted by so few costumers. Logically, they focused their efforts in developing technologies for processing the most widely grown and used grains, such as rice, wheat or soy. In view of that situation, the quinoa processing industries had to use adapted technology originally developed for wheat or rice processing, making use of different production parameters and production scales. The technological adaptation under such conditions caused problems related to processing capacity and efficiency.

Without appropriate production factors, and the lack of a specific combination of them, the quinoa sector had deficiencies in increasing its processing capacity and adding value to the product under competitive conditions. There was, consequently, a huge necessity for better production technology, locally developed, efficient, adequate to the needs and particular characteristics of the sector, and economically accessible to all quinoa-processing companies.

Problems detected in the quinoa sector can be seen in other Bolivian agricultural sectors; for instance, the production and processing of annatto, Brazil nut, tarwi, *cañagua*, sesame and amaranth. All of these products have great potential for growth and insertion into national and international markets. Therefore, we believe that the experience that is reported below is replicable in other Bolivian economic sectors.

[1] Celiac disease is a disorder resulting from an immune system reaction to gluten, a protein found in wheat and related grains, and present in many foods, resulting in diminished nutrient absorption in the body.

Overview

After the CP assessments in quinoa-processing companies, where the characteristics of the technology used were also evaluated, the necessity to embark on the development of new technology became evident. The problems identified in the quinoa-processing companies can be summarized as follows:

- Significant losses of raw material (grain), with the consequent increment in the quantity of residues discharged.
- Low quality of the grain.
- High specific consumptions of water, electrical energy and gas, with the consequent increment in production costs.
- Intensive use of labor force, with the consequent increase in operation costs.
- Wastewater with high contents of saponins, with the consequent pollution of bodies of water.
- Unfeasibility of recovering pure saponin, with the consequent loss of its commercial value.

The main causes of these problems and the respective technological solutions that were proposed are as follows.

a) Use of adapted technology in an inadequate manner for processing quinoa. For instance, the use of rice peelers for the scarification of quinoa. This caused not only product losses, but also a loss of grain quality. To solve the problem, an efficient system of dry cleaning was designed, constructed and implemented. The system used the inherent abrasive properties of quinoa for scarification, through friction between grains. In addition, a system of saponins recovery was installed in order to recuperate this important sub-product that was previously being wasted.

b) Washing systems with a wide range of residence time. Quinoa-processing companies used washers with turbulent flows in order to accelerate the washing process and eliminate the saponin remaining on the grain. When water flow is turbulent, quinoa grains exit the washer randomly; that is, the last grain entering the washer can be the first to come out, or the first one entering can be the last to come out. This produces two negative effects: (i) in the case of a short residence time in the washer, grains come out badly washed and must be re-washed, consequently increasing operation costs; (ii) in contrast, with a long residence time, the grains are excessively moistened as well as increasing their processing time, energy costs for drying, and reducing product quality due to the dissolution of salts, proteins and starches in the washing water. To arrive at the solution for this problem resulted in the design of a washer which accomplishes the simulation of a laminar trajectory of the grain, through the use of a turbulent flow. This guarantees that the first grain entering the washer is the first one exiting. In addition, the system reduced the average time of residence in the washer, from 22 minutes to 4.7 minutes

c) Drying systems with insufficient air flows, which allowed the re-humidification of the grain in a significant percentage. The new drying system design is highly efficient. It employs a turbine which generates a greater air flow with lower energy consumption. The efficiency of the turbine is 76%, almost double that of similar turbines manufactured in other countries.

d) Use of technology that did not allow the recovery of sub-products of high commercial value. For instance, saponin, which has a high economic value in the market. Using older technology, saponin was contaminated with impurities from the quinoa and particles detached from the grain itself. As a result, the price of saponin decreased by 70%. Moreover, in various cases, saponin recovery was not at all possible.

e) Use of technology that operated in small batches (not continuously). For instance, the centrifugation operation was carried out in batches of less than 20 kg and demanded an intensive labor force with exclusive dedication. The new technology operates in a continuous manner and demands few personnel.

f) Excessive, and in some cases, unnecessary number of unit operations in the process, with the consequent use of an excessive number of machines associated with each of the unit operations. For example, after the washed grain drying and centrifugation process, which takes into account a previous destoning system, and in spite of the existence of a prior, initial dry cleaning operation, the grain was cleaned again using various machines including additional destoners, venting machines, an optical colored particles selection system and, finally, a manual impurities selection system carried out by personnel exclusively dedicated to this purpose. The new technology is more efficient in each of the steps in the drying and wetting process; for this reason, there is no need to include additional cleaning unit operations after these processing steps have been concluded.

To solve these problems CPTS developed and implemented a new technology based on Cleaner Production. The technological innovation have had a positive impact on the productivity, it has also resulted in a considerable reduction on the environmental impact and has come concurrently with a convergence process in productivity indicators, as its described in the next section.

Benefits

In order to illustrate the impact of the application of the new technology on productivity, various tests and measures were carried out in three companies which are responsible for 47% of quinoa exports. Seven indicators were used to make it possible the comparison of efficiency levels before and after the implementation of the new technology.

Absolute Indicator	Irupana – La Paz		AVSA – La Paz		ANAPQUI - Oruro		Relative Indicator	Irupana Change (%)	AVSA change (%)	ANAPQU change (%)
Resource Use	Before	After	Before	After	Before	After	**Resource Productivity**			
Electricity use [kWh/year][1]	114.481	64.452	89.492	42.242	117.222	27.282	Electricity savings	44%	53%	77%
Thermal Energy Use [Mcal/year]	992.325	222.045	334.530	98.280	265.323	170.886	Thermal Energy savings	78%	71%	36%
Water Use [m^3/year]	25.152	16.997	13.230	5.670	14.540	6.746	Water savings	32%	57%	54%
Raw material use [tons /year]	2.345	2.181	1.029	1.010	1.910	1.662	Raw material savings	7%	2%	13%
Pollution Generated	Before	After	Before	After	Before	After	**Pollution Reduction**			
Air emissions [tons of CO_2 equivalent/year]	54	30	42	20	55	13	Emissions reduction	44%	53%	77%
Reduction in discharges of saponin [tons/year]	98,25	-	47,25	-	74,95	-	Reduction in discharges of saponin	100%	100%	100%
Reduction in product losses [tons/year]	318,3	194,5	77,5	60,5	322,3	146,9	Reduction in product losses	39%	22%	54%
Biochemical Oxygen Demand - BOD_5 [2] [tons/year]	152,9	70,0	46,3	21,8	145,3	52,9	Reduction in DBO_5	54%	53%	64%
Production Output	1.960 tons/year		945 tons/year		1.499 tons/year					

Source: IRUPANA, AVSA, ANAPQUI and CPTS

(1) Calculated based on the emission factor of the grid in the national interconnected system is 0.47 t CO2e per 1,000 kWh generated.

(2) It is estimated that 1 kg of grain provides 360 g of BOD5 and 1 kg of saponin powder provides 390 g of BOD5.

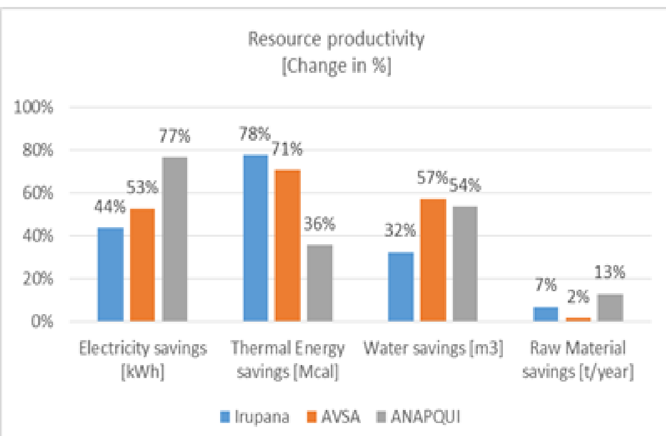
It is worth highlighting that the increase in efficiency evolved simultaneously with a convergence process of the productivity indicators (see Table below). The reasons for such a convergence are: (i) the substitution of batch operations by a continuous process, and (ii) the exhaustive technical training provided to the employees at the time the new technology was installed. This training allowed the "homogenization" of the operations management through procedures using parameters control and the establishment of production protocols. Before, no norms or procedures were followed.

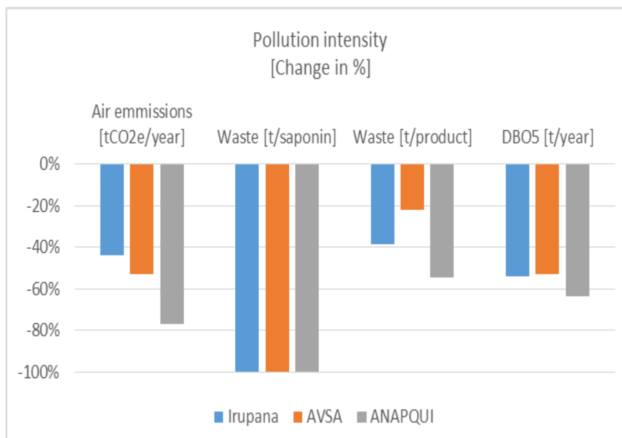
The standard deviation is used as a dispersion measure of the inter-company productivity. With the exception of the water specific consumption indicator, all efficiency indicators show a lower inter-company standard deviation after the implementation of the CP technology. This signifies a greater convergence in the productivity of the sector.

Productivity indicators	Inter-company Standard Deviation before the new technology	Inter-company Standard Deviation After the new technology
Electricity specific consumption [kWh/ ton of processed grain]	14.9	6.3
Water specific consumption [m^3/ ton of processed grain] (*)	1.8	2.1
Thermal energy specific consumption [Mcal/ ton of processed grain]	133.8	5.8
Global yield [tons of processed grain/ ton of raw grain]	0.05	0.02
Labor force use [man-hours/ ton of processed which grain]	51.1	3.75
Capital use [US$ of machines and equipment/ ton of processed grain]	103.7	64.8

(*) The increase in the Inter-company Standard Deviation is due to problems in the lay out of the new installations at one of the processing companies.

RECP Profile





Resource Efficient and Cleaner Production (RECP)

Resource Efficient and Cleaner Production (RECP) entails the continuous application of preventive environmental strategies to processes, products and services to increase efficiency and reduce risks to humans and the environment.

RECP addresses three sustainability dimensions individually and synergistically:
- *Production efficiency*
  > Through improved productive use of natural resources by enterprises

- *Environmental management*
  > Through minimization of the impact on nature by enterprises

Human development
  > Through reduction of risks to people and communities from enterprises and supporting their development

Success Areas

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Principal Options Implemented	Benefits obtained by three companies (IRUPANA, AVSA and ANAPQUI)*			
	Economic		Resource Use	Pollution generated
	Investment [USD]	Cost Saving [USD/yr]	Reductions in energy use, water use and/or materials use (per annum)	Reductions in waste water, air emissions and/or waste generation (per annum)
Technology replacement	450.000	1.082.000	Electricity: 187.219 kWh/year Thermal energy: 1.100.967 Mcal/year Water: 23.510 m^3/year Grain: 316 tons/year Saponin: 220 tons/year	CO2 eq = 88 tons/year Waste water: 23.510 m^3/year DBO_5 = 200 tons/year

*Estimates made for a total production of 4.409 tons/year

Approach taken

CPTS carried out Cleaner Production (CP) assessments in five main quinoa-processing companies. These CP assessments were the basis for approaching a more ambitious project --the development of new technology for quinoa processing. The old technology was so inefficient that nothing from it was taken into account to design the new one. To develop the new technology CPTS got funds from international cooperation for the execution of a demonstration project aimed at designing and constructing an entire quinoa processing plant, based on Cleaner Production (CP) principles and adapted to the needs of the existing quinoa processing companies. The technology was designed by CPTS, constructed by Industrias Metálicas Andinas (IMA) and installed at AVSA.

The first prototype of the new technology began working in AVSA and increased its processing capacity, reduced its operation costs, increased its cash flow and improved its environmental performance indicators. The success achieved with the implementation of the first prototype led to the establishment of an alliance between CPTS, IMA and AVSA. The alliance aimed initially at consolidating the work relationship that arose between these companies during the prototype development phase. In the long term, the purpose has been to focus the joint effort in research and development activities within the quinoa sector.

As soon as the dissemination of the technology began, other companies and institutions joined the alliance, which resulted not only in the establishment of the formal ‘Quinoa Alliance´ but also in the rapid adoption of the technology. At the present time, 85% of Bolivian quinoa exports is processed with this technology.

Business case

The technological innovation in quinoa grain processing have had a significant impact on the productivity of the Bolivian companies dedicated to this activity, which has resulted in a considerable augmentation of its exports and the sector’s growth. This has come concurrently with a convergence process in productivity, the consequence of the process mode modification (of replacing batch operations with a continuous process) and the introduction of homogeneous production protocols inherent to the new technology.

The positive results obtained have led to the natural creation of an alliance among the most important companies of the sector: producer associations and technology manufacturers. To the extent that a small program such as the Quinoa Alliance has gotten tangible results, other institutions, public and private, have shown more interest in actively participating of the process. Hence, it is possible to think that in some cases where government capacity is limited in terms of generating and coordinating larger development programs, it is useful to concentrate intervention efforts into more limited and well-focused areas. This will trigger positive effects and lead to actions by the rest of the actors and sectors.

In order to reach the expected objectives, the technological innovation must come with parallel innovations in the institutions that promote development. The public sector has an important role to play in boosting coordinated policies aimed at promoting the adoption of these innovations. The generation of technology as well as its adoption is affected by deliberated public policies (e.g. infrastructure development, research funding and activities of agricultural extension), not deliberated policies (e.g. changes of commodity prices), and activities of the private sector. One of the challenges related to the design of development policies based on technological change is an optimal integration of public and private efforts.

Testimony Box
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English Abstract (where applicable)
The Centre for Promotion of Sustainable Technologies (CPTS) is a civil non-profit association. Its main objective is to assist Bolivian institutions, entities, municipalities, companies and industries to meet challenges relating to sustainable development through sound cleaner production (CP) and energy efficiency (EE) practices and technologies. The purpose is to achieve an optimal use of resources (water, energy, fuels, etc.) in all sectors in order to improve their productivity and environmental performance, with the ultimate aim of contributing with the sustainable development of the country and region. CPTS's institutional mission is "to improve the competitiveness of companies from various sectors of the economy, based on the introduction of the philosophy and practices of cleaner production". With more than 20 years of experience, CPTS constitutes the cleaner production leading organization in Bolivia as strong expertise has been built up in cleaner production, energy efficiency and pollution prevention assessments, sustainable management of resources, scientific research and development of sustainable technologies. From this perspective, cleaner production is a preventive strategy, which encompasses energy efficiency and pollution prevention.

ABOUT *RECP EXPERIENCES*

Through the joint Resource Efficient and Cleaner Production (RECP) Programme, the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Programme (UNEP) cooperate to improve the resource productivity and environmental performance of businesses and other organizations in developing and transition countries. The Programme is implemented in partnership with the Global Network for Resource Efficient and Cleaner Production (RECP*net*). This series of enterprise success stories documents the resource productivity, environmental and other benefits achieved by enterprises in developing and transition countries through the implementation of RECP methods and practices.

These successes were achieved with the assistance of the National Cleaner Production Centres, which are part of RECP*net* established with support of the UNIDO and UNEP. The success stories employ the indicator set described in *Enterprise Level Indicators for Resource Productivity and Pollution Intensity*, UNIDO/UNEP, 2010. The primer with accompanying calculator tool and further case studies are available at www.recpnet.org, as well as on www.unido.org/cp and www.unep.fr/scp/cp.