International Journal of Agriculture and Forestry 2013, 3(1): 16-28
DOI: 10.5923/j.ijaf.20130301.04

An Exergeticcold Chain Methodological Analisys Onhorticultural Productive Chains to Evaluate Productivity and Competitiveness: Study Case Andean Blackberry

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Abstract This research has resulted in a methodology of exergy analysis of main requirements to implement cold chain models in agribusiness productive chains, which improve the productivity and competitiveness indicators that contribute to accomplish demands on product quality for minimally processed and processed products for domestic and international markets. Based on the model of links and segments, which in the case of the agricultural sector involves activities from the primary producer to the end user, are analyzed in a cross-linked and their current status, the requirements in terms of product distribution logistics of the cold chain, as a mechanism for keeping quality of the products to the end consumer. Given the requirements of the cold chain, the models proposed in the literature were analyzed, from conceptualization and identification of critical control points. Finally methodology evaluates the product exergy losses along the production chain for scenarios in which contemplates the use and non-use of the cold chain, from a thermodynamic analysis, interpretation contemplating thermoeconomics and its impact on productivity and competitiveness indicators considering fresh Andean Blackberry (RubusGlaucus) as a study case.

Keywords Production Chain, Cold Chain, Exergy, Thermoeconomics, Productivity, Competitiveness, Andean Blackberry

1. Introduction

Farming and agroforestry from the perspective of developing countries, should be benefited from the processes of Research, Development and Innovation (R&D&I) in order to increase productivity and competitiveness, given its great social, political and economic incidence, constituting one of the pillars on which the country develops economically and which involves much of its rural and industrial human resources. In this context, the ultimate aim of all productive sector is to offer differentiated products with quality standards consistent with the requirements demanded by the specific market of interest, based on the time variable as the critical factor that limits the performance of supply chains but not the only one that should be controlled within the distribution process from the producer to the end customer. In what is known as the logistic distribution system of products and services, joins a range of factors to consider, which, permanently affect productivity, becoming part of the strategic direction that allows the chain to adapt to changes market[1].

Within the agriculture and agroforestry in Colombia, diversify a large number of subsectors each with specific problems within their strategic direction needs focus on increase their technological and non-technological, capacities being a particular case study horticulture[2], which seeks to meet fluctuating demand in quantity and quality ([3]).

Narrowing the specific processes that involve the formation of foodstuffs at horticultural production chain within the degrees of transformation to which a product is subjected to cool, the successful integration of the supply chain in terms of product quality, falls in effective management of the "cold chain"[4], a logistics network system within a production system, equipped with transport

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Published online at http://journal.sapub.org/ijaf

and storage technology that ensures the quality of fresh and frozen food in nature, from the producer to the consumer[5], to extend the useful life of products[6], that in low temperature conditions for the particular case of fresh or refrigerated varies between 0℃ and 10℃, whereas for frozen products must be below 0℃.

This leads to the need for an evaluation methodology supported by an analysis of critical control points in a concatenated integration of a cold chain model intoa productive chain which characterize the potential and actual risks in the handling, transport and disposal product based on a model that integrates logistics distribution chain model with a model based cold chain temperature and critical control points for food products in fresh, minimally processed and processed from the system guidelines Hazard Analysis and Critical Control Points (HACCP).

2. Methods and Materials

The structuring methodology is developed in four phases that allow reaching integrative assess changes in indicators of productivity and improving competitiveness against material loss by exergetic evaluation in a model of integrated production chain technological and non-technological inputs cold chain from the HACCP regulations. These phases are adapted to the Andean Blackberry productive chain as a case study.

●Phase I: Structuring the supply chain model of links and segments.

●Phase II: Analysis of cold chain models, selection based on the supply chain and the chain link.

●Phase III: Rating exergy losses of product through the production chain with and without cold chain.

●Phase IV: thermoeconomics evaluation of productivity and competitiveness indicators.

2.1. Phase I: Structuring the Supply Chain Model of Links and Segments

Modern analysis of global value chains emphasizes the relationship between actors as a mechanism to reduce uncertainty, improve access to key resources and increase the efficiency of the system[7]cited by[8]. Coordination is therefore a key source of competitiveness that is sometimes called "collaborative advantage" or "comparative advantage of cooperation"[9]cited by[8].

The model of the horticultural production chain design, provides the conceptual and methodologies established in sectoral characterization studies, which comprehensively covers the interaction of actors throughout the production process[10]. According to[11], the supply chain is the set of components interacting in the agribusiness environment of a country or region, including production systems, suppliers of inputs and services, production and processing industries , distribution and marketing agents and consumers, where the flows of material, information and capital are the mechanisms linking the various actors in the chain (production units), which seek to provide and ensure to the consumer market products with a high quality degree[12]. These mechanisms (supply chain, logistics methodologies, specific brands such as cold chain, etc.), Differentiating to become competitive with peer environments in the world market.

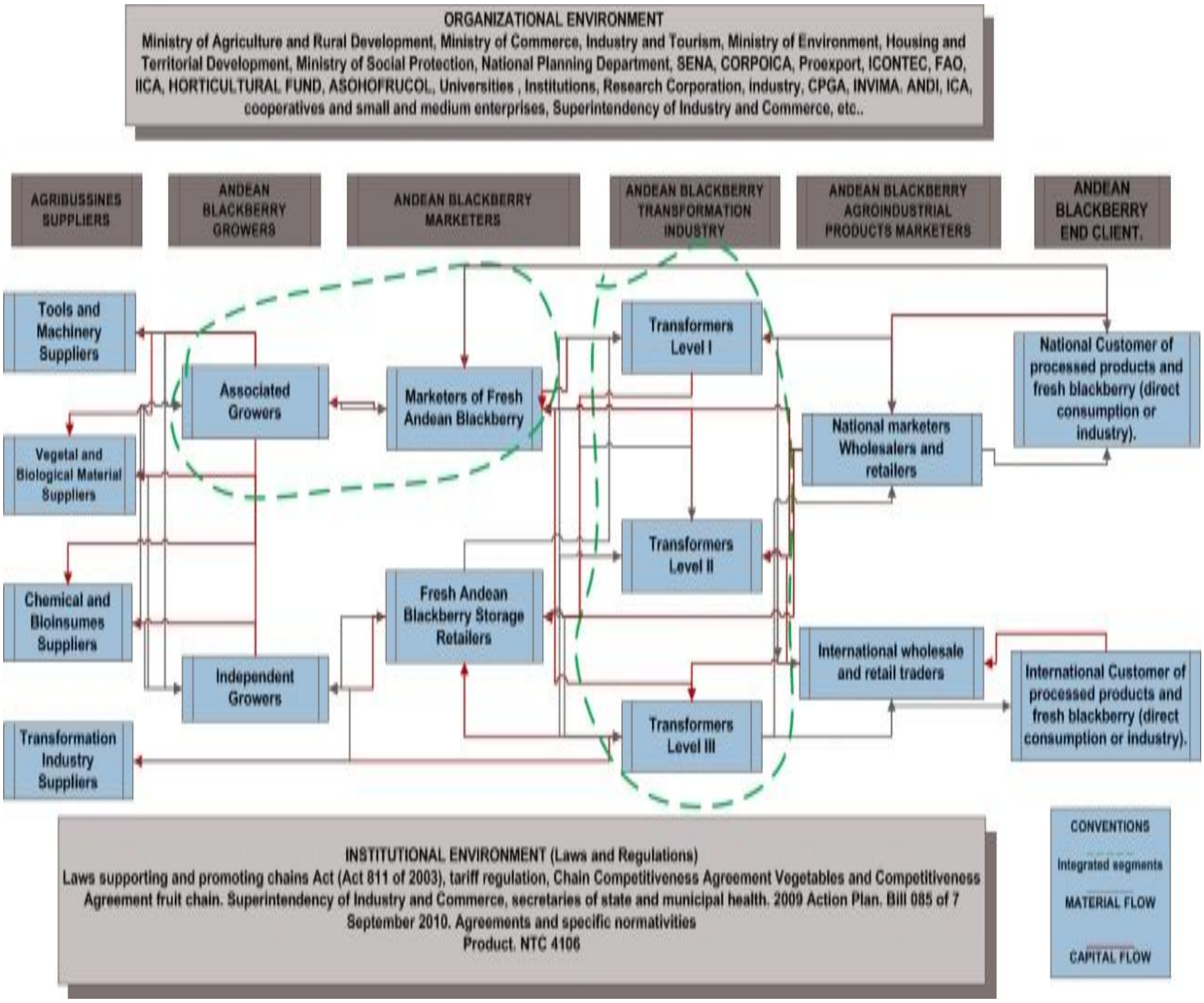
The productive chain (PC), is articulated in terms of activities for product development, structuring links or clusters. The link is the unit of analysis defined as groups that include a set of actors relatively homogeneous in terms of their characteristics, production techniques, common raw materials, intermediate or final uses common and similar production technologies. Table 1, presents a description of the links and segments that make up the horticultural production chain.

Figure 1 shows the standard model adapted to Andean Blackberry which allows its use as an analysis tool that will address the integration of the cold chain as a key element in the distribution of products from the producer to the end customer.

Understanding the current dynamics of the production process chain of blackberry, represented linkage model has clear interactions between blackberry growers, marketers directly and indirectly to the end customer, but there is no detailed information the way they handled the delay in the production units of agro processing link. In this sense the approach of the cold chain (CC) joint with productive chain(PC) will focus on integrated links growers, traders, wholesalers and retail traders and end customers.

The supply chain model that is constructed to analyze and depicted in Figure 1, where there are six links through which the final product is developed. The product chosen for the methodological study is fresh or minimally processed Andean Blackberry commercialized in the national market. Theproduct flow to analyzeacross the PC is presented in Figure 2.

An important factor in the management of the cold chain in the selected route, is to record the temperature of fresh product throughout the distribution process[15]which contributes to an optimal level of traceability, integration with policies and quality standards of the food industry (such as HACCP) compliance and tolerance limits[16],[17];[18],[19] cited by[15], where the activities of monitoring and control of temperature throughout the distribution process logistics cold chain horticultural directly influence economic, technological and non-technological requirements, focused on the end customer.



Source: Own elaboration on basis of information compiled from [13] and [14]

Figure 1. Standard model of the production chain for Andean Blackberry

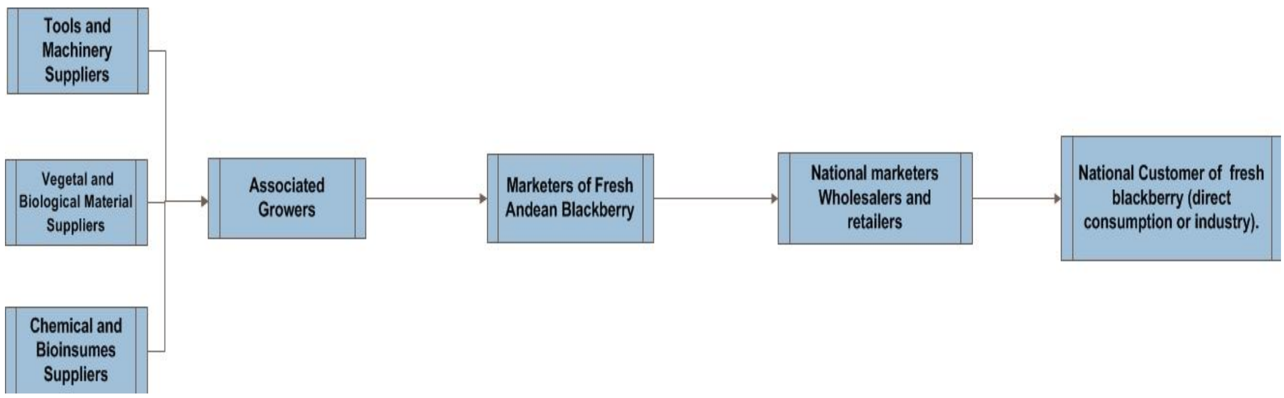


Figure 2. Fresh Andean Blackberry Road in the productive chain

Table 1. Characterization of the links in Horticulture PC

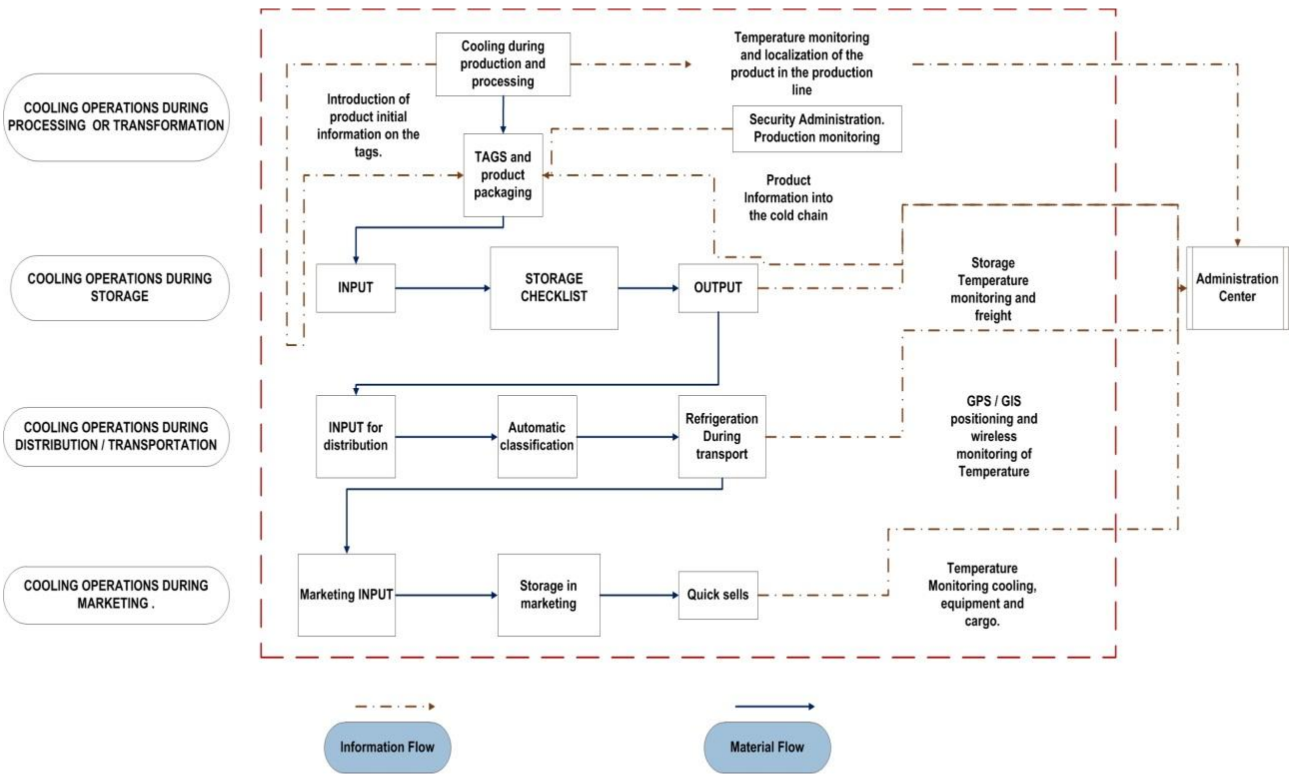
LINK	SEGMENTS	DESCRIPTION	PRINCIPAL SEGMENTATION VARIABLE	OTHER SEGMENTATION VARIABLES
Suppliers of inputs and services	Suppliers of tools and machinery. Suppliers of biological material, plant. Suppliers of agrochemicals and input processing. Supplier of materials for the food industry and agro processing.	The first link in the chain, which groups the members related to the supply of inputs, planting material and other products such as machinery and inputs for transformation industry to the link producers.	Providing input type	Logistics capacity.
Primary producer	Technifiedproducers Not technifiedProducers	Concern to the technified andnottechnified producers of horticultural products different regions of the country.	Technological level of the production unit.	Crop extension Production capacity
Traders of fresh horticulture products	Marketers for the domestic market. Marketers for the international market.	Integrates the actors responsible for product marketing fresh or minimally processed domestically and internationally.	Served market segment	Coverage Logistics Capacity
Marketers of horticultural products for agribusiness.	Storage retailers Wholesale marketer	This link integrates both collectors and wholesalers of fruits and vegetables, which come to be the bridge between the producer and Agribusiness.	Mechanisms of interaction with the predecessorslinks.	Logistics Capacity
Agro processing	Level I Transformers Level II Transformers Level IIITransformers	This link brings together all those companies whose economic activity involves processing of fruits and vegetables	Degree of transformation of the fresh product.	Market demand. Production Quantity
Marketers of agribusiness	Marketer of products domestically (domestic consumption). Marketer of products internationally (export).	This link is made by operators in charge of marketing, both domestically and internationally. At the international level are international traders and brokers, while nationally marketed aboard superstores, hypermarkets, supermarkets and national processing companies.	Specialized market	Logistics Capacity
Final consumer	Domestic final consumer. Importer final consumer.	It covers operators and consumers demanding either processed or processed or fresh chain.	Segment to which it belongs	Talkconsuming.

2.2. Phase II: Analysis of Cold Chain Models, Selection based on the Supply Chain and the Chain Link

The analysis conditions of the cold chain, starting from the concept of customer perceived quality compared to the products and the quality offered by the producer, in relation to the conservation process to which they are subjected[20], since the post-harvest handling of product, as final product or as an input for the processing industry, handling affects differentiated and specific criteria in the same way it is contextualized with the cost management and the energy crisis[21].

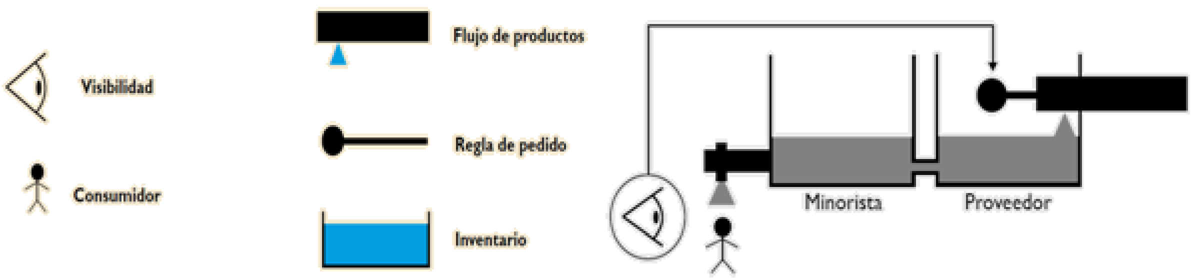
The articulation of the cold chain (CC) with the productive chain (PC), starts from the temperature monitoring and control of times, both in storage and transport, is part of the fulfillment of norms explicit focus to the product itself, in standards quality in each link that are testable, verifiable and traceable through the system of hazard analysis and critical points (HACCP) should be adaptive to the specific product and the chain link that is applied, taking into account that the link in which the product remains in a longer time is marketing.

9 models were evaluated for cold chain (1) traceability model for production units, (2)traceability of the cold chain systems, (3)radio frequency identification (structured frameworks), (4)Model Security System for cold chain, (4)Integration model of the consumer or end customer to cold chain monitoring model CF food from RFID and integration with the client, (5)Model cold chain logistics based on focus just in time (JIT), (6)Traceability of products for smart RFID TAGS, (7)Direct distribution model and node, (8)Model of multi-temperature distribution nodes and (9)RFID integrative model for the links in the chain of distribution and production, the latter being selected for horticultural PC (See Figure 3).



Source. Adaptedfrom[22]

Figura 3. Integración de la tecnología RFID a la cadena de frio para productos alimenticios



(a)Elements of the model (b) Model of synchronized chain

Source: From Canella, 2010

Figure 4. Analytical model for supply chain

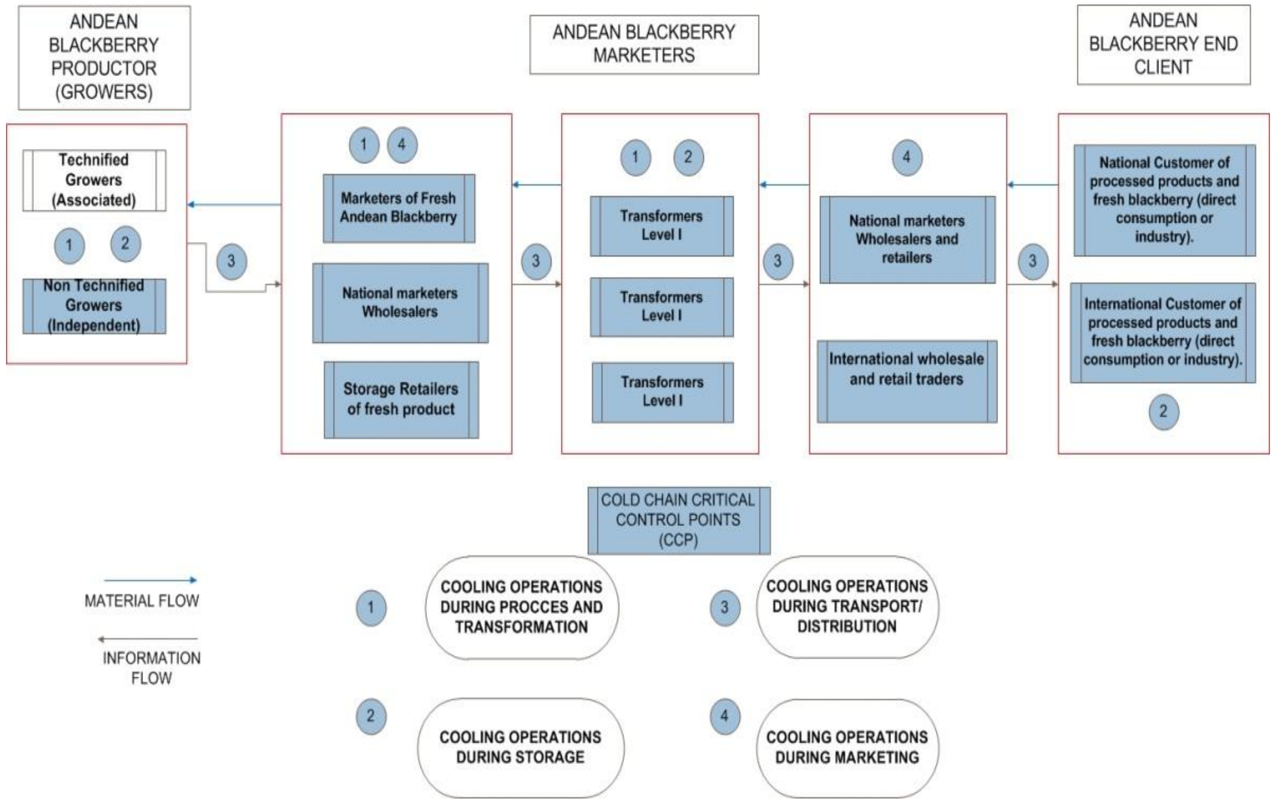
The proposed integrated model, through RFID TAGS track aims PC products throughout the CC, in the stages of processing, storage, distribution and marketing of the supply chain which have correspondence to producers, processors, traders and consumers or end customer, in real time, where the temperature management as a control critical variable is subject to minimize the time of operation which implies logistics costs in equipment and methods.

The integration of the cold chain to productive chain, is performed based on the concept of supply chain, which evaluates the four archetypes to analyze horticultural production chain (PCHF).Based in Forrester the integration model identify based on common points of the PC and CC are namely: traditional supply chain, shared information,requests managed by input supplier and synchronized chain. According to[23]cited by[24], analysis of the four archetypes is performed under the proposed model of water tank. (See Figure 4).

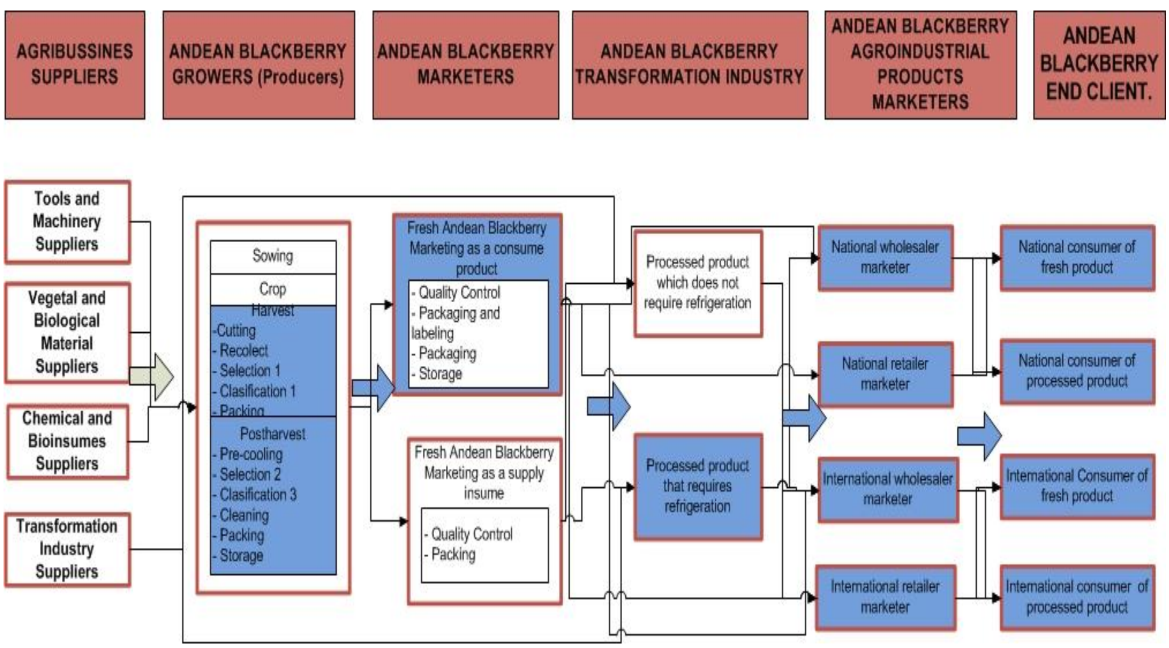
The selected archetype is synchronized chain given the required informationhomogeneity along CPHF depending on the product temperature, this integration model unified inventory to fulfill orders in a timely manner articulating some link segments, which bring it within the model collaborative chain. In this case there is direct communication between marketers and processors to manage the amount of producers as well as real-time control of material flow.

In Figure 5 (a), we have that links in the PC analysis against the cold chain are the same as are contemplated in the supply chain, in this sense, the integration model of the PCand CC, structure horizontally between the segments of the links producers, marketers of products for agribusiness, agro-processing, marketers of agribusiness and end customer integration blocks are handled for these three links, where the link marketers integrates segments corresponding to the CP of traders and processors, in the case of Andean blackberry (See figure 5b)

From the selected route the critical control points (CCPs) are established on the links, associated with the need for temperature management, directly involving a technological need for storage or transport, as specified in the model CCPC in Figure 5b. Given this, Figure 6 shows the path model for PEFC fresh blackberry, requires 4 stages of cold storage and refrigerated transport 3, subject to technology assessment.

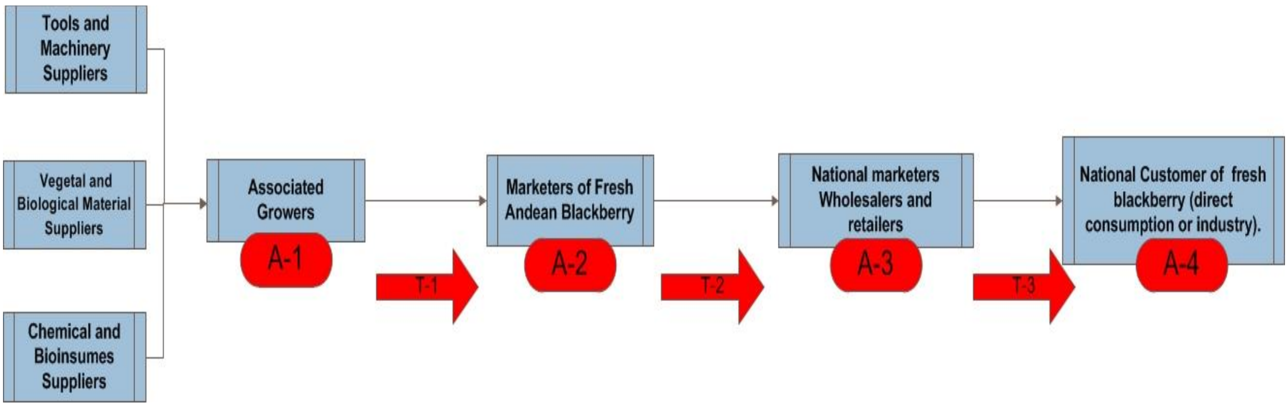


(a) Standard Model



(b) AndeanBlackberry CCPC integrationmodel
Source.Authors

Figure 5. Integrated cold chain to productive chain model



Source.Authors

Figura 6.CPCF para mora en fresco

The description of each of requirements and recommendations stages in terms of the cooling or chilling requirements, are described in Table 3.

Table 3. Identification of factors on the CCP for fresh Andean Blackberry route

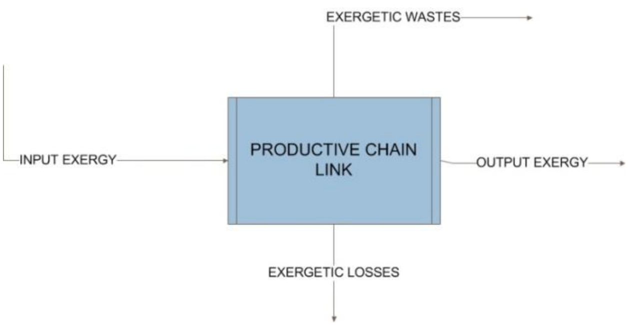
STAGE	MONITORINGCONDITIONS	ACTUAL TECHNOLOGY	DESIRED TECHNOLOGY
A-1	● cutting: product maturityConditions (levels 4,5 and 6 color index). ● Storage capacity in the baskets and their distribution ● Temperature 5 °C - 1 °C in precooling. ● Relativehumiditycontrolled.	● Handling of plastic baskets to minimize losses by mechanical damage or moisture. ● Storage at ambient conditions of cultivation. ● Initiativesto manage cold water as the primary coolant. ● Ice management initiatives in the baskets. ● Cooling in situ.	● Integration of packaging to ensure minimize mechanical damage and preserve the product in precooling.
T-1	● Time product life 8 hours after cutting. ● RelativeHumidity (RH)environment. ● T should not be above 25 °C ● Transportationprecoolingconditions. ● Distancesto the collection of primary marketer.	● Transport conditions guaranteeing against mechanical damage. ● No control handles temperature and moisture. ● Avoid contact of the product with the weather. ● Subject to exogenous factors such as road conditions.	● Refrigerated transport with air cooling technology to control T and RH. ● Monitor the performance of the variables through RFID technology, extended to the segments involved in the process chain.
A-2	● Cooling temperature 1 °C ● RH in the range of 90-95%. ● Distribution of packaging according to arrival and departure times of product.	● Refrigerators and standard cold rooms. ● Management of different products as market seasonality. ● Classification by maturity	● Cold rooms with T and RH control, traceability and RFID tracking variables. ● Specialization of cold storage for fresh products.
T-2	● Cooling temperature 1 °C ● RH in the range of 90-95%. ● Distribution of packaging According To arrival and departure times of product.	● Refrigerated trucks supplied by the customer. ● Refrigerated trucks supplied by the bidder.	● Refrigerated Trucks with T and RH control and tracking RFID traceability.
A-3	● T 1 °C cold room for storage. ● T of 5 °C for storage and display on refrigerated shelves.	● Marketers wholesalers have the appropriate technology. ● Traders do not handle retail refrigeration.	● Implement current technology to track traceability. ● Adapt basic cooling technologies by retail marketers.
T-3	● Maintain product temperature up to the end use site.	● Transportation in non-refrigerated vehicles.	not applicable
A-4	● Store in refrigerator cooling standard temperature or freeze as cultural use of the product.	● Standard Refrigerators	not applicable

Among the activities planned for the structuring of the CC by CCP, the precooling is an activity that is not yet structured into postharvest link by growers, thus controlling the cold chain at this point depends on the proper classification and disposal of arrears in collection packs according to the Colombian Technical Standard[25].

2.3. Phase III: Rating Exergy Losses of Product through the Production Chain with and without Cold Chain

The exergy concept is based on the first and second laws of thermodynamics, which in contrast to the energy, this is exempt from the law of conservation, since the availability input exergy into a system always exceeds the output exergy. All actual process has lost exergy or irreversibilities, associated with the first process exogenous and endogenous factors other, this energy or work available is called exergy, which measures the ability of a power source to produce useful work. In accordance with[26] cited by[27], is defined as the maximum work that can be obtained from a system.

Exergy analysis, did not include the law of conservation of energy, since its purpose is to estimate the maximum amount of work that can be obtained in each of the links, where the irreversibility of the process is directly related to the CCP and potential losses ofproduct. In accordance with[28], cited by[27], the flow exergy per link should include the inputs and outputs described in Figure 7.



Source. Compiled from information in[26]
Figure 7. Exergy flows provided by link in the CPHF

Figure 7, provides that for each link should look for activities that take place in it, for the development of exergy calculations necessary to establish baseline data for the analysis of the product, which is extended to each of the segments and transport and storage stages. In this sense, it is necessary to analyze the data required for each link as a function of temperature and flow of material.

According to the Department of Agriculture (USDA), in their publications[29],[30] and[31] and in[32], the calculation and thermodynamic properties estimation should be performed depending on the temperature at which the interest food is, having an estimate of the composition according to the nutritional content considering only the fractions of water, protein, fat, fiber, ash and carbohydrates[33] cited by[34]using the specific heat at constant pressure (Cp). For the specific case of Colombia ICBF provides the nutritional content for Andean blackberry Blackberry. In Table 4, these values are entered for a portion of 100g.

Table 4.standardcomposition on Andean Blackberry for evaluation of thermophysical properties

Fraction	ICBF AndeanBlackberry Colombia
Humidity (Water content)	93,3%
Protein	0,6%
Fat (Lipids)	0,1%
Fiber	0
Ash	0,4%
Carbohydrates	5.6%

Source. Compiled from data in[35]

The chosen product for exergy analysis is fresh Andean Blackberry, subjected to a cooling process in the cold chain. Refrigeration is suggested product instead of freeze according to literature disclaims of damage suffered by the delay when is subjected to a T below the freezing point. Unbound moisture is not considered in the calculation of the fraction properties of ice formed during freezing. Data were taken ICBF fractions, since these reflect the composition of the blackberry variety of the country. Table 5 sets out the conditions to analyze the 4 links.

Table 5. Conditions for each link to the exergy analysis

ANALIZED LINK	WITHOUT COLD CHAIN	WITH COLD CHAIN
CROP	Te = 14℃, Ts = 14℃ 44 crop losses% Hr = 80-90%	Te = 14℃, Ts = 14℃ 44 crop losses% Hr = 80-90%
PRODUCTION	Tamb = 14℃ Losses of 10% in transport to the collection	Tamb = -2℃ (Ice) Te = 14℃, Ts: 5℃ No losses
STORAGE	Tamb = 10℃ Te = 11℃, Ts = 2℃ % Of lost without good management 50%	Tamb = 1 °C (cold room) Te = 11℃ Ts = 10℃ % Of lost 1%
DISTRIBUTION	The storage conditions are the same for transportation if we neglect the variability of microclimates in the path loss of 25%	The storage conditions are the same for transportation if we neglect the variability of microclimates in the tour. Missed 1%

Source.[33];[34];[36]

Equations 1 through 13 constitute the thermodynamic model used to evaluate the exergy available depending on the material in scenarios with and without cold chai. Equations 14, 15 and 16 are used to calculate the exergetic and economic efficiency of the PC with and without CC.

(1) $\dot{Ex}_T = \dot{Ex}_F + \dot{Ex}_C + \dot{Ex}_P + \dot{Ex}_Q$

(2) $\sum \dot{Ex}_{in} - \sum \dot{Ex}_{out} = \sum \dot{Ex}_{w+l}$

(3) $\dot{Ex}_{Heat} - \dot{Ex}_{work} + \dot{Ex}_{massin} - \dot{Ex}_{massout} = \dot{Ex}_{w+l}$

(4) $\dot{Ex}_{inTotal} = \dot{Ex}_{outproduct} + \dot{Ex}_{outwastes} + \dot{Ex}_{outlosses}$

(5) $W_u = \sum_{e=1}^{n}(h_{in} - T_0 \dot{s}_{in}) - \sum_{e=1}^{n}(h_{out} - T_0 \dot{s}_{out}) + \sum_{i=1}^{n}(1 - \frac{T_0}{T_i}) dQ_i - T_o s_g$

(6) $C_p(fruit) = \sum_{i=1}^{n} C_i w_i$

(7) $h(fruit) = \sum_{i=1}^{n} h_i w_i$

(8) $s(fruit) = \sum_{i=1}^{n} s_i w_i$

(9) $\Delta s = \int_{T_1}^{T_2} \frac{dQ}{T}$

(10) $Q_1 = mC_p(T_2 - T_1)$

(11) $e = \frac{T_1 - T_2}{T_1}$

(12) $\Delta s = \frac{Q_2 - Q_1}{Q_2}$

(13) $\Delta s = \frac{m_{out}\, C_p(T_2 - T_1) - m_{in} C_p(T_2 - T_1)}{T} = \frac{(m_{out} - m_{in}) C_p (T_2 - T_1)}{T} = (s_2 - s_1) = C_p Ln(\frac{T_2}{T_1})$

(14) Exergetic Cost= $\prod E_x = \frac{UnitaryCostofOperation \quad (\frac{\$}{Kg})}{Exergyoperation \quad (\frac{J}{Kg})}$

(15) $ExergeticEficience = \frac{Exout}{Exint}$ operation to operation

(16) $EconomicEficience = \frac{\prod Ex\,out}{\prod Ex\,in}$

For Andean blackberry productive chain exist country indicators to assess their competitiveness by specialized government agencies in agriculture estimates those in order to generate competitiveness and productivity indicators assuming for the particular case of this product two scenarios, one without and one with cold chain

Competitiveness indicators to evaluate are[1]:

● Trade Balance: The trade balance is the registration of imports and exports of a country during a period. The balance of it is the difference between exports and imports.

● Apparent consumption (Yij+Mij-Xij): Apparent consumption expressed product availability consuming a region, country or countries in a given period of time. Is estimated based on domestic production plus the trade balance and the inventory consumption. In the case of perishable goods, apparent consumption is being equal to its availability as no inventories or stocks are present.

● Tradability (Xij-Mij)/(Yij+Mij-Xij): This indicator is a relationship between net exports (exports minus imports) to apparent consumption (domestic production plus imports minus exports). For foreign trade, the indicator is used to keep track of the gain or loss of the export capacity of the country that produces the good. When the indicator is above zero, the export sector is considered, because there is excess supply, ie, is a competitive sector within the country. When the indicator is less than zero, it is possible that this is an import substitution industry, or non-competitive with imports, as there is excess demand.

● Relative Trade Balance (Xij-Mij)/(Xij+Mij): It measures the relationship between a product's trade balance (exports minus imports) and the total sum of exports and imports of a country.When the RTB is between -1 and 0, indicates the strength of the nature of the importing country, the value -1 being the end where the country imports all of the product and does not export anything. When not in the extreme value, there is a greater amount of import what is exported. When the indicator for a product in this range, it is said that the country is a net importer of this product. When the indicator value is zero, indicating that the country exports the same amount of product that matters. It may also be that the country is producing the amount consumed domestically. When the indicator value is between 0 and 1, indicates that this product exports are greater than imports. When the value is equal to 1, but no matter exporting country significant amounts of product. When the RTB for a product is in the range of 0 to 1, says the country is a net exporter of the product.

● Comparative Advantage (Product Exports / Exports Country) / (World exports of product / total world exports): Measures the performance of trade in selected countries for a product in relation to the goods and the rest of the world.

● Specialization Index (Xij-Mij) / Exp country's total: For a certain period (set of years, or a given year), this indicator shows the degree to which the net flow commercial (trade balance) of a product from a country participating in the quantum of exports of that product in the world, or for a specific market, in this case the world market. That is, expresses what percentage of exports of the product made by the world, it is up to each producer.

Productivity indicators are:

● Sales price

● Utility

● Number of dwelling in optimal state to market

● Earned Value

● Total value of production

● Economic Efficiency

3. Results

The estimation of entropy and enthalpy as a function of the specific heat (Cp), is done with an evaluationsoftware of thermophysical properties designed by the Ibero-American Science and Technology for Development, and Treatment applet in Food Preservation XI version associated with the Polytechnic University of Valencia, which includes developments estimation of thermodynamic properties of fruits and vegetables developed by[31] cited by[32] and are considered inputs for analysis cited[27] and[36].

The results are recorded in Table 6.

[1] http://ww.agronet.gov.co

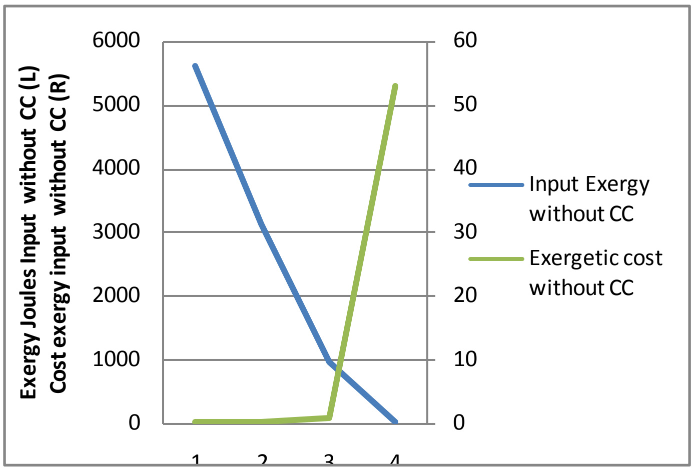
Table 7 is a comparative analysis of exergy and economic results for the chain for both scenarios with cold chain and without cold chain for Andean blackberry.

Considering that average losses in Colombian crops of Andean Blackberry are 30-40%, the transportation and handling losses of 50% to reach the wholesale marketer when not handled cold chain for the product, is necessarythat comparison scenarios contemplate a significant decrease in the% loss allowed to the implementation of technology in storage and transport within the joint of the cold chain, and the final destination of the product that can be domestic consumption or export to markets and potential. Table 8 shows the competitiveness indicators for the two scenarios and Table 9 productivity indicators.

Table 6. Evaluation results for the PCexergy of blackberry, fresh blackberry product, scenarios with and without cold chain

ANALIZED LINK	AVAILABLE EXERGY OR USEFUL WORK WITHOUT COLD CHAIN	AVAILABLE EXERGY OR USEFUL WORK WITH COLD CHAIN
CROP	3138.35J	3138.35J
PRODUCTION	945,28J	2330,49J
STORAGE	15.54J	1359.67J
DISTRIBUTION	-43.12J	1359.67J

Table 7. Final methodological analysis

<table>
<tr><th>Discussion</th><th>Analysis Chart</th></tr>
<tr><td>The input material for each link, segment or stage of analysis within the PC, is the starting point for the analysis of material loss and exergy losses for delinquent chain without CC, the exergy available decreases from cultivation (1) to distribution (4), with the CCP storage stage (3). The input exergy available in this CCP is 900J/Kg exergy and cost about $ 8 / J. The exergetic cost increases with the absence of technologies that control the variable T, to $ 53 / J</td><td>
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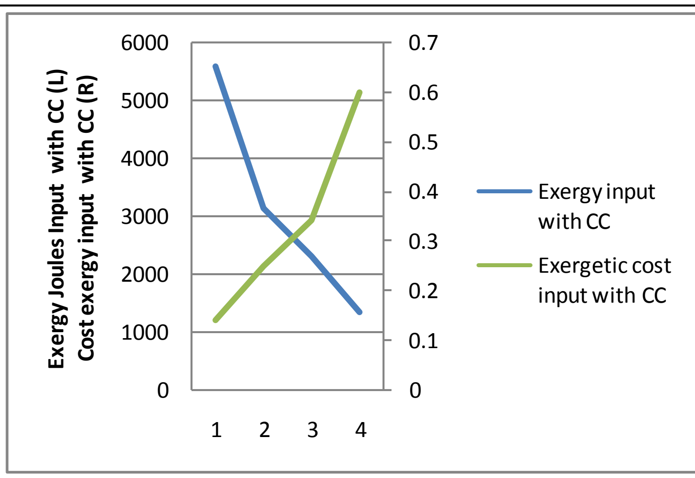
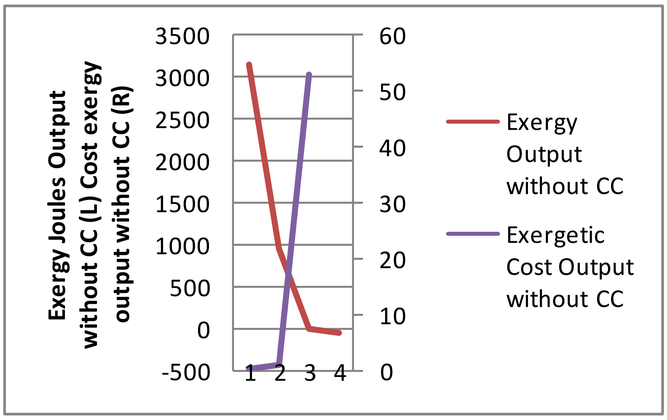
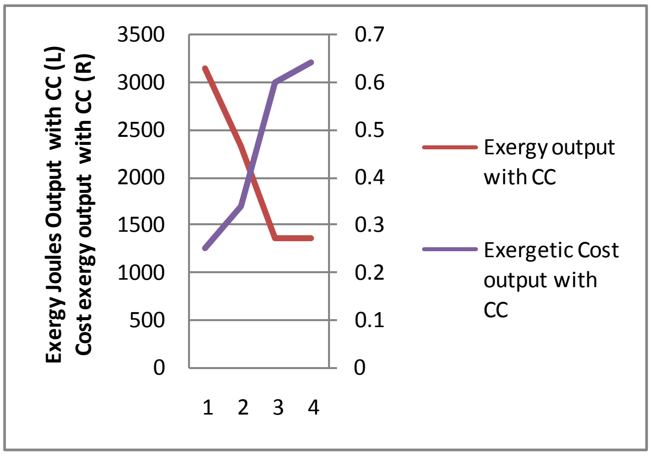
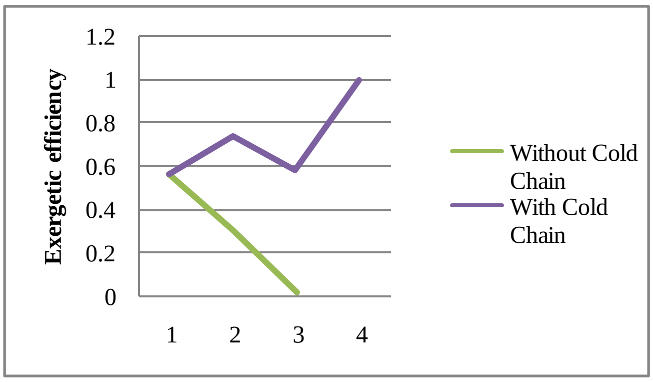
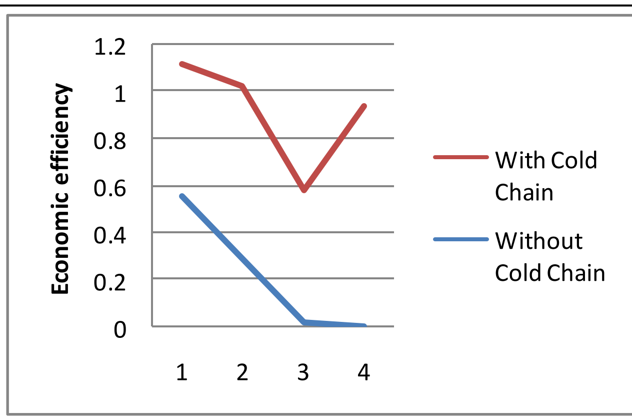
<tr><td>For a scenario with CC, just as there is a clear decrease in available Exergy understanding that are considered the same% loss at the beginning of the PC without CC, however the available exergy input storage CCP is 2700J / kg approximately, for a unit exergetic cost of 0.3 $ / J, a $ 07.07 value / J less than without CC. The exergetic cost increases with the use of technologies that control the variable T to a maximum of $ 0.6 / J approx.</td><td>
</td></tr>
</table>

<table>
<tr><th>Discussion</th><th>Analysis Chart</th></tr>
<tr><td>The exergy available at the output, is directly related to the material available in optimal conditions to move to the next stage in the PC. For the scenario without CC exergy tendency decreases to 0, because of the losses of each stage this being consistent with the national indicators where the overall loss product to the end consumer is about 65%. Exergy is available 700J/Kg end with approximately 17J/Kg exergetic cost.</td><td>
</td></tr>
<tr><td>On stage with CC exergetic cost sustainably increases in the outputs of each link from 0.25 to $ 0.63 / J, where the PCC is 0.42 $ / J for approximately 2100J/Kg exergy available. Again indicators with CC are better than without CC.</td><td>
</td></tr>
<tr><td>The exergetic efficiency comprehensively evaluates the use of exergy along the PC. For the scenario without CC, efficiency tends to 0 as the product passes through all the stages of the process, whereas with CC, there is variability considering CCP in which there are minimum losses, however never efficiency is below records without CC</td><td>
</td></tr>
<tr><td>Economic efficiency is related to the variation in comparative exergetic cost without cold chain efficiency decreases to 0, since the cost increases more and more. For the scenario with CC, the variability of this maintains a level above 60% in each stage.</td><td>
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</table>

Table 8. Indicators of competitiveness

Competitivenessindicator	Ideal Scenario	Actual Scenario
Trade balance:	Ton 15549.71 not recorded imports of the product	9Ton
Apparentconsumption:	Ton 8363.99	99172,7 Ton
RelativeTrade Balance:	1	1.00
ComparativeAdvantage	Given that the net value of 15549.71 Ton for 1880USD/Ton unit value, you have a total export value of 29233.4548 thousands of USD. TheCAis 18, 48	0,0107488880.00
Tradability	0.19	0
Specializationindex	0.073%	0,00004%

Source.Calculated with information taken from www.agronet.gov.co, www.trademap.org, made from ITC calculations based on UN COMTRADE statistics

For an average sales price of $ 2991/Kg kilogram, a producer price of $ 799/Kg without CC and with CC$871.315/Kg, productivity can be assessed before and after the CC. Table 9 shows the calculation of productivity for both scenarios the real and the ideal considering only factor net.

Tabla 9. Indicadores de Productividad para la mora de Castilla en Cundinamarca

Scenario	Without Cold Chain	With Cold Chain
Productor Price	$799/KgCOP	$871,315/KgCOP
Sales Price	$2991/KgCOP	$2991/KgCOP
Utility	$2192/KgCOP	$2119,7/KgCOP
Product amount (Andean Blackberry)	13290.35 Ton	21530,367 Ton
EarnedValue for commercialized product	$29.132.447.200COP	$45.637.918.929,9COP
Total productionvalue	$21.237.979.300COP	$23.160.162.620,5COP
Economic Efficency	137,2% Earned 37,2%	197% Earned 97%

Although in terms of utility unit, the profit margin of the cold chain is lower considering a unit cost of product superior in $72,315COP/kg, the amount available expected product can have a marketing value greater product, with an expected profit for the department with respect to production cost of 97% compared to 37.2% profit with no cold chain.

From these results and considering the two scenarios without and with CC are estimated indicators of productivity and competitiveness, under the assumption that the cold chain scenario, comply with the implementation of technological equipment in storage and process to minimize product losses in the stages of storage, transportation and marketing, with the geographical reference to Cundinamarca, with average production for 2010 of 26,580.7 Ton de Mora lost an average of 35% crop, availability becomes Mora of 17,277.455 tons of which globally for cold chain would have an efficiency of 90% is the end product of export or for domestic consumption would be available Ton 15549.71 with optimal quality requirements.

4. Conclusions

● Temperature, humidity and time are key control variables of horticultural products, these can be controlled, monitored and modified through the cold chain as an integration tool in process and product technology directly linked to the activities of proper storage and transportation logistics distribution models and inventories.

●The consolidation of the PC model, the identification of synchronous chain archetype, to adapt optimum cold chain models identified for food handling and perishability grade products for temperature, through the joint CCP allows to formulatethe integration model of the CCPC.

●The results for PC with CC show increasing link by link exergetic cost sustainably by minimizing product loss due to the T, while for the PC without CC fixed costs increase and are increasingly representative in the unit value of the product, which leads to the conclusion that the implementation of cold chain in horticultural production chains affects overall quality and economic efficiency of these

●It is important to consider establishing an integrative scheme between chain model and a model of technology transfer, under the current guidelines established and directed against technology gaps

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