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FRUIT INDUSTRY IN THE HIGH VALLEY OF THE NEGRO AND NEUQUEN RIVERS (Argentina)

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Abstract:

This report presents a brief description of the Apples and Pears Industry Supply Chain of the "High Valley of the Negro and Neuquén Rivers" (HVNNR) in Argentina.

It is aimed to provide a base to discuss a research project involving the modeling and optimization of the short and long term operation management in the industry.

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1. INTRODUCTION

The “High Valley of the Negro and Neuquén Rivers” (HVNNR) is an area belonging to the states “Río Negro” and “Neuquén” at the south-west of Argentina. There is an important fresh fruit and concentrate juice industry in that area.

This industrial activity recognizes four fundamental stages. They are:

1. ***Fruit Production*** (as an agricultural process): It is the fundamental stage of the activity that goes from the plantation of the different fruit varieties until the ending of the crop.
2. ***Fruit Industrialization***. It starts at the crop and comprises different processes (like classification, washing and packaging), made on the fruit destined to the refrigeration or commercial channels.
3. ***Cold Conservation***: It comprises the conservation of the fruit in bulk or packed in cooling chambers until the moment of their processing or delivery to the different markets.
4. ***Commercialization***: It is the most complex aspect of the apples and pears industrialization business and it encompasses all year round without interruptions. There is a permanent interaction of the marketing office and the packing and cold conservation steps.

These stages are repeated in an annual cycle, being the harvest time (since early January until late May) the most active period in the cycle.

Most of the companies operating in the fruit industry in the area of the Negro and Neuquén Rivers Valley include in their businesses all the steps along the supply chain. This situation leaves an interesting management and optimization problem that each company has to deal with. Moreover, the optimal operation of the whole supply chain had become extremely important for the Argentinean companies to stay in the market. This is so, because during the last few years some Asian countries had enter at a competitive level into the juice and fresh fruit international markets (like USA and some European countries) traditionally covered by the Argentinean companies.

Normally, each company covers the following steps in the pears and apples industrialization process:

i. Fruit production in own farms (they work as “producers”).
ii. Fruit purchase to third parties producers.
iii. Fresh fruit and products (refrigerated fruit and juice) transportation among farms, refrigeration chambers, ports, and domestic and regional markets.
iv. Fruit cold storing and packaging.
v. Fruit selling in different markets.
vi. Making own marketing.
vii. Designing and construction of fruit containers.
viii. Operation and maintenance of refrigerating systems.
ix. Etc.

The industrialization activities during the annual cycle are habitually divided in different phases, which operate in a superposed form with the agricultural activities in the farms. Considering only the strictly industrial activities, the companies normally operate in such a way that a chronology for the annual tasks is established, once the export commitments assumed by the company commercial office have been set. This timetable is not produced in a systematic way, and several re-scheduling have

to be made along the cycle to adjust some of the decision to the crop or market contingencies. These changes are always performed “manually”, based on the plant personnel experience.
Consequently, it seems that there is a lot of room in the way the industry actually works, to systematize the decision taking procedure. Many of these decisions have to be taken in a daily way during the crop period. Therefore, it is expected that an optimal supply chain management strategy would be of great impact on the company’s profitability.

2. DEFINITIONS

Woods.

Area of land covered with the fruit trees.

Quality.

Strictly it refers to the **sanitary quality** of the fruit. This is a measurement of the defects, internal pressure and degree of sun exposition. It also considers esthetic aspects like color, form, deformations, etc.

Normally, three types of different qualities are considered:

- **Category I:** without defects of any kind.
- **Category II**: with some type of scarce appearance defects.
- **Category III**: with a permitted limit for defects but always in acceptable sanitary conditions, that is to say without diseases.

The fruit that exceed the quantity of defects established for the Category III, or present lesions that they could house diseases (fungi development) are considered discard.

***Bins from Woods*.**

Bins containing warm fruits gathered from the fruit trees in the farm with motive of the harvest.

***Bins of Cold*.**

Bins containing fruit, which come from process machine, and goes to cold storage.

Bins from Prepackaging.

Bins that contain fruit from a washing process, treatment, or pre-selection of sizes, that comes from cold storage.

Refrigerating Chamber.

It is the plant where the fruit is stored at low temperature. There are two types of refrigerating plants.

- Conventional Cold-Storage Plant or **C**onventional Cooling **C**hamber (CC).

- Controlled Atmosphere Cold-Storage Plant or **C**ontrolled **A**tmosphere Cooling **C**hamber (CAC).

3. CALCULATION OF THE PROCESSING VOLUME

Normally, the total amount of fruit to be processed by a company (fruit from own or third party farms) is calculated based on the fruit volume destined to overseas markets (USA and Europe), committed with anticipation by the marketing office. The reason is that the overseas markets impose the higher fruit quality standards, like fruit of Sanitary Category I and certain specified sizes that determine the amount of fresh fruit that have to process to reach that demand.

Let's consider the case that 20,000 package of 20 kg each one, are demanded by the overseas markets. Typically from the total amount of fruit to be processed by the company, only 50 % have the Sanitary Quality I required for overseas markets. From this amount, only 50 % have also the required sizes for this market. That is, 1,600,000 kg of fruit must be processed to obtain the demanded 400,000 kg. These two factors are subject to uncertainty, varying from year to year depending on the goodness of the harvest and also on the way the fruit is manipulated during the harvest. Different harvest manipulation strategies producing better fruit quality are possible at higher costs. This establishes a compromise between quality and cost along the supply chain that should be ideally resolved in a systematic way.

The remaining 1,200,000 kg that are non good enough for overseas markets includes:

- ***Fruit of Sanitary Categories I*** in sizes non exportable to overseas markets. This fruit is suitable for domestic or regional markets, like the Brazilian market.
- ***Fruit of Sanitary Categories II and III***. Selected sizes are commercialized in the Brazilian market and the remaining fruit goes to the domestic market.
- ***Wasted fruit***. These fruit is used for the concentrate juice production.

The total amount of fruit to be processed, might also includes fruit of optimal quality entering to conventional or controlled atmosphere storages to attend the domestic and regional market during out of season periods.

4. ANNUAL CALENDAR OF ACTIVITIES

a) ***September:*** Evaluations of commercial results for the current year***.***

b) ***October:*** Elaboration of the commercial program for the next year.

c) ***October and November:*** Pre-commercial agreements with the customers for the next year.

d) ***November and December:*** Preparation of commercialization programs including shipments, volumes and destinations.

e) ***December:*** * Determination of volumes for export commitments.

* Estimation of the production volumes from own farms for the next year.

* Determination of fruit volumes to buy to third parties farms.

* Purchases of packing and transportation materials, input and papers.

f) ***September to December:*** Processing of fruit from controlled atmosphere cold storage.

g) ***December and January:*** Elaboration of the total production program for overseas markets.

h) ***January 12th to May 31st:***

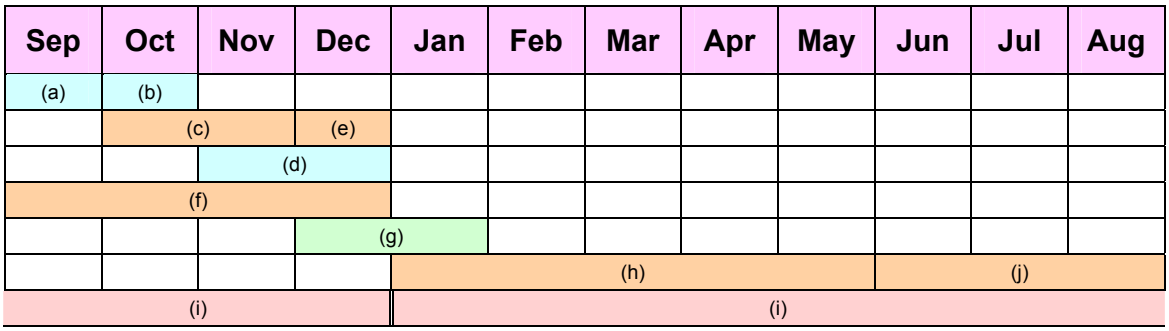
* Harvest period.

* Beginning of introduction of packaged fruit into the cold chambers for storage. Bins of warm packaged fruit also enters into the cold storage to obtain the temperature level (1°C) required for dispatching it to ports.

* Period of processing of fruit in machines for overseas markets.

i) ***January 12th until December 31st:*** Operation period for the classification and packaging machines.

j) ***From June to August:*** Post-harvest period. Processing of fruit from conventional cold storage (until it is exhausted) to supply the domestic and regional markets.



5. HARVEST

There exist several types of harvest procedure, depending on the packing requirement and on the moment it is accomplished, given that the fruit variety has a limit of about 25 days to be fully harvested. The beginning of the harvest starts the commercial effect called “Primicias", that pays overprices of up to 100%. This implies that an early harvest is economically convenient; nevertheless, not all the fruit can be harvested together because there are important differences of ripeness among the same fruit. For this reason normally partial harvest are made, usually called “passing”, were only a given percentage of the fruit is obtained.

Due to cost reasons, the number of passing is normally limited to two. The first one is made gathering from the trees pieces of fruit with such characteristics (size, color, quality, internal pressure, etc.) to produce a high efficiency in the classification process, and minimizing the fruit waste in this way. In the second passing all remaining fruit is gathered, which means that it will includes pieces of fruit of every size, quality, color, deformations, etc. This produces quite different classification efficiency, despite it is fruit from the same trees.

A correct decision of the number of passing, based on an economic trade-off between harvesting costs and processing efficiencies, it is necessary to optimize the company revenues. The optimal number of passing could also be distinct for each fruit variety. The varieties and harvest period of the apples and pears growing in the area of the Negro and Neuquén Rivers Valley are the following:

January - February	:	Pear Williams
February - March	:	Pear Beurre D´Anjou
March	:	Pear Beurre Bosc and improved red apples
March - April	:	Pear Packams Triumph and Net Apple Delicious
April - May	:	all Red and the Granny Smith (Green) apples.

6. MARKETING.

The commercialization office of the company defines the delivery commitments for the different markets:

a) ***Overseas***. Export by maritime route: Traditionally to Europe (Holland, Belgium, Norway, Finland, Germany, Italy, and Spain) and USA.

b) ***Regional*** (Brazil): Export by land route using thermal trucks. Clients include several importers of San Pablo, Brasilia, etc.

c) ***Domestic*** (Argentina). Transport by thermal trucks to Buenos Aires City markets, and eventually others of different parts of the country.

Each particular market has their own preferences about the characteristics of apples and pears. These preferences have to do with quality, sizes, color, defects, treatments, containers, etc. Therefore, each commitment of shipment to the markets have to be defined by volumes of fruit according to size, type of container, color, minimal internal pressure, admissible maximum dosing for each type of post-harvest pesticide, pre-shipment control for insects detection, etc. This originate that the preparation of dispatching programs is not a trivial task. The delivery programs must take also into account the quite strict sanitary control that has to be performed previous to every shipment to overseas markets. The control must be accomplished at the cold storage chamber, with samples from a minimal of 20 pallets. If any evidence of insect presence is detected, the batch of fruit in the storage chamber must be discarded and then it is necessary to re-schedule the delivery plan.

Each destination determines their own preferences in relation to the type of fruit and also on the processes to be accomplished. For example, the fruit with destination to Holland must be of variety Red Delicious, with a size 100, 75% color, crated in containers type Mark IV and covered with wax. Additionally, it must travel in the same ship as other request of the same fruit, size, container and color with destination to Norway, but without wax. These competition problems for the same fruit, in the same moment, with only different process in the waxing tunnel, produces countless transport inconvenient that can duplicate or triplicate the efforts of the packing process.

A systematic management of the supply chain to deal with all these market preferences seems again to be essential to keep the companies at a competitive international level.

7. PROCESS DESCRIPTION.

This is the activity of greater responsibility in all the organizational plan of a company. Given the exportation commitments assumed by the marketing office, they should be fulfilled in time and form dispatching the fruit to the different markets. The raw material provided by the farms during the harvest period must be classified in volumes of fruit by size, pressure, color and quality according to the specification in the purchase orders, particularly those coming form the overseas customers.

Packaging

Under this name, normally are included several task as described below. These task starts with the arriving of bins from woods containing the warm fresh fruit.

1. The bins from woods enter to the machine input system, generally an automatic floating system using water treated with fungicides. The fruit enters to the pre-classification table where the damaged fruits are separated as waste.

2. The bins of fruit from woods that enter with destination to conventional or controlled atmosphere cooling receive a treatment with pesticides in a module for bins washing call Drenching, where the rest of land and fungus spores are eliminated from the fruit that will stay several months in cold. The apple Granny Smith is treated with an anti-scalding chemical that protects the skin of the apple against scalds produced during the cooling process.

3. The fruit that continues the process travels until the washing module, where the washing is made with water containing special chemical products. The fruit is them rinsed at the exit of the module and goes through dryers. Once dry, it enters to the waxing module where it is sprayed with wax, and them it is send to a drying tunnel with hot air to dry the wax.

4. In these conditions the fruit enters in the classification sector where it is separated in the three mentioned categories, according to the degree of defects or damage

that present the pieces. This task is connected with the work made by the workers at the pre-classification stage.

5. Once the fruit has been classified by quality, it enters the sector of sizing or weighting, depending on the technology that possess the machine. Each fruit sized or weighted enters into a drum with the corresponding size, and then it is introduced into a selling container by the staff of crated, according to the characteristics of the container and the specifications made by the client. In general, the characteristics of the crated are quite complex. They can be with or without paper, with or without tray, or several intermediate types, etc.

6. To process fruit without wax, simply the waxing module is by-passed.

7. The containers of the same type are stowed in pallets according to their sizes in refrigerating chambers. They are identified with stickers (containing stamps and bar code). The fruit temperature is decreased until the specified dispatching temperature. The type of pallet used is provisory o permanent according to the waiting time available before the dispatching to port.

Periods of Packaging.

Below is a description of the different periods for the packaging process according to the origin of the fruit and the destination markets.

- ***January to May***. Packing in Warm: fruit comes directly from the woods. Destination: Overseas.
- ***June to August***. Packing in Conventional Cold: fruit from conventional cold storage. Destination: domestic and regional markets.
- ***September to December***: Packing of Controlled Atmosphere Cold: fruit from controlled atmosphere. Destination: domestic and regional markets.

Cold Storage Plants.

The cold-storage plant starts to work during the beginning of the crop (January). It receives fruit from two sources:

i) bins from woods that exceed the processing capacity of the day. This fruit will give work to the packing machines if the crop is interrupted by rains.

ii) pallets of crated fruit that begin to be produced in the packaging machines.

The higher cold demand is produced in the period March-April, with the entering of:

a) Pallets of crated red apples and pears
b) Bins of good quality red apples from woods
c) Crated red apples improved for Controlled atmosphere
d) Bins of apples for export and conventional cold

e) Bins with Packams Triumph pears from the last part of the crop.

While the apples and pears crop is ending, it starts the closing of controlled atmospheres chambers. A balance is established among the last income of fruit from

8. QUALITY CONTROLS.

The fruit receives a quality control during the entering to the establishment, making measurement of the fruit maturity (level of dissolved solids, sugars, pressure, etc.). Thereafter routinely controls are accomplished during the processing steps, by taking samples from the crated fruit in the chambers and revising the classification by quality, size, control of weight of container and type of accomplished conditioning.

9. GENERAL COORDINATION OF ACTIVITIES.

During the crop period the coordination of the activity is accomplished from the Programming and Control sector of the company, supervising day to day the production parameters for each destination, instructing permanently modifications in the crop paces, imposing minimum fruit diameters and fixing internal pressures standards in order to assure the volumes of production with the required quality by the clients. This office also permanently accomplishes a task of stock control, by daily monitoring the arrival of trucks with warm fruit from the woods.

10. ENERGY AND ENVIRONMENTAL CONSIDERATIONS

Conventional and Controlled Atmosphere Refrigeration Systems.

These facilities need electric power for driving:

i) ammonia compressors of the refrigeration cycle,
ii) pumps for pumping the ammonia to the evaporators,
iii) pumps of water condensers,
iv) pumps for the compressors cooling water,
v) evaporators fans and,
vi) fans for the cooling tower condensers.
vii) It is also required electric energy for the illumination of the chambers and storage areas.

The energy consumption of these facilities strongly depends on their design, type of technology used for stowing (self-elevators or other devices) and the way the refrigeration chambers are operated (frequency for the opening and closing of the doors). The strategy for the opening and closing of the chambers is one of the issues that should be considered as part of the management of the supply-chain.

The environmental impact of the refrigeration system is almost null and void. Small amounts of make-up water are required because evaporation in the cooling towers.

Some waste is disposed from the defrost process, where the ice can be contaminated with pesticides from the fruit.

Selection, Conditioning and Packaging Plant

Electric energy is required for the pumps of the hydraulic transport system, belt carriers, sizing machines, packaging machines, self elevators and lighting system. The level of energy consumption is also strongly dependent on the available technology, maintenance policy and the way the system is operated. Another required energy source is the natural gas used as fuel to operate the hot air drying tunnels.

The environmental impact comes from the effluent generated by the make-up water in the hydraulic transport, and from the washing and pesticide fruit treatment. But the higher pollution in the overall fruit industrialization process is produced at the factories that manufacture the packing inputs. The wastes from these plants are disposed into the courses of water that are used for the effluent drainage. The pollutants are the chemists employed for the treatment of the paper and the molded pulp.

Plant of production of Concentrated Juice.

The energy consumption (electric power and natural gas) in the concentrate juice plants is much higher than in other installations. This is because the raw material suffers a strong transformation from fresh fruit to concentrate juice, requiring intensive energy use.

The fuel is mainly used for steam generation (saturated steam at 1 MPa and 180ºC approximately) used in the juice pre-concentrator and concentrator. In this case the level of energy consumption varies from plant to plant depending on the technology used, and within each plant on the degree of process automation and the way it is operated.

The impact on the environment is of great importance, because the disposed effluent has some content of organic matter. This impact can be substantially reduced if the wastes from the process (pear and apple residues) are used in agricultural applications, for example, as animal food, natural fertilizers, etc. The volume of organic effluents that is disposed depends on the type of technology used in the treatment process.

11. SUPPLY CHAIN SCHEME

The Figure below presents a preliminary scheme of the Supply Chain for the apple and pear industrialization process in the area of the High Valley of Negro and Neuquén Rivers.

The boxes in the figure represent a task o series of task, while the lines or arrows are the interconnecting flows of fruit between the different stages of the supply chain. A list describing each of these task and lines is also presented.

Description of the Tasks in the Figure

1. **Own Farm:** Farm of property of the company where it is cultivated and harvested the fruits to process in the industrial plant.
2. **Local Trucks Transportation:** Trucks conditioned to transport the bins of fruit from the Farm until the industrial plants. They are units of medium size to take the fruit along relatively short itineraries (in the area of the High Valley).
3. **Third Party Farm:** Farm of property of third where the fruit is cultivated and harvested, and where the company acquires it to process in their industrial plant.
4. **Drenching:** The bins of fruit from woods that enter to conventional or Controlled Atmosphere cooling, receive, in a laundry of bins called Drencher, a treatment with pesticides. The goal of this task is to eliminate the land and fungus spores from the fruit that will remain in cooling chambers for several months. This is achieved by dropping a rain of conditioned water - with the appropriate products - over the box of the transportation truck. Furthermore, a treatment anti-scald is applied to the Granny Smith apples to protect the skin against scalds that may appear during the cooling process.
5. **Pre-Classification:** The bins from woods enter to the access system machine, generally an automatic hydro-immersion system, where the fruit is floating in water mixed with fungicides. Then, the fruit is captured by a conveyor belt and it goes to the pre-classification table whose main objective is to discard the fruit with quality lower than Category III. This selection process is done by qualified workers.
6. **Conventional Cold-Storage Plant:** It has several chambers where it is controlled the temperature and humidity of the stored product. The tasks in this plant consist of: mounting of the bins or pallets, opening and closing the chambers. The method used in carrying out these operations has strong influence in the consumption of energy of the plant. The conventional cold-storage plants have a great activity during the harvest and post-harvest periods.
7. **Controlled Atmosphere Cold-Storage Plant:** it has several chambers where it is controlled the temperature and the humidity of the stored product and it is also limited the oxygen concentration of the air to approximately 2%, to reduce the vital rhythm of the product and to improve the quality at the end of the process. As the chambers are filled they are being closed and they aren’t being open until the packed fruit is shipped to the markets or the fruit stored in bins is processed.
8. **Washing, Waxing, Drying:** after the pre-classification, the fruit that will be processed goes to the laundry module. It is washed with special products, rinsed, and sends to the dryers. Then, it enters to the waxed module where is sprinkled with wax and finally, it goes to the drying tunnel module to complete the wax drying process. This process can vary according to the client's demands.
9. **Classification:** the fruit that leaves the drying module is captured by a conveyor

belt and it goes to the classification table where it is separated in three categories according to the degree of defects of each fruit and the work of the qualified people.

10. **Sizing:** Once the fruit has been classified by quality it enters to the sizing and weighing process according to the technology of the machine. Each sanitary quality is separately processed.
11. **Concentrate Juice Plant:** the fruit coming from the Farm and from discard is stored in storehouses waiting to be processed by the mills and concentrate juice plant. This plant has an important consumption of energy and it is a key part of the fruit agriculture as since it process about 50% of the farms production.
12. **Packing:** Once the fruit is sized or weighed, it enters in the corresponding size drum. Then it is packed and organized in a container according to the characteristics of the containers and the client's specifications. This process is semiautomatic. The bundles are placed over pallets and they are derived to the refrigeration chambers.
13. **Concentrate Juice Cold-Storage Plant:** Cold chambers are arranged to store concentrated juice packed in two modalities: special bins and barrels.
14. **Thermal Trucks Transportation:** Trucks are prepared with a thermal box and an autonomous refrigeration system which allows maintaining the temperature of the product during their transfer to destination. These trucks are prepared to travel long distances.

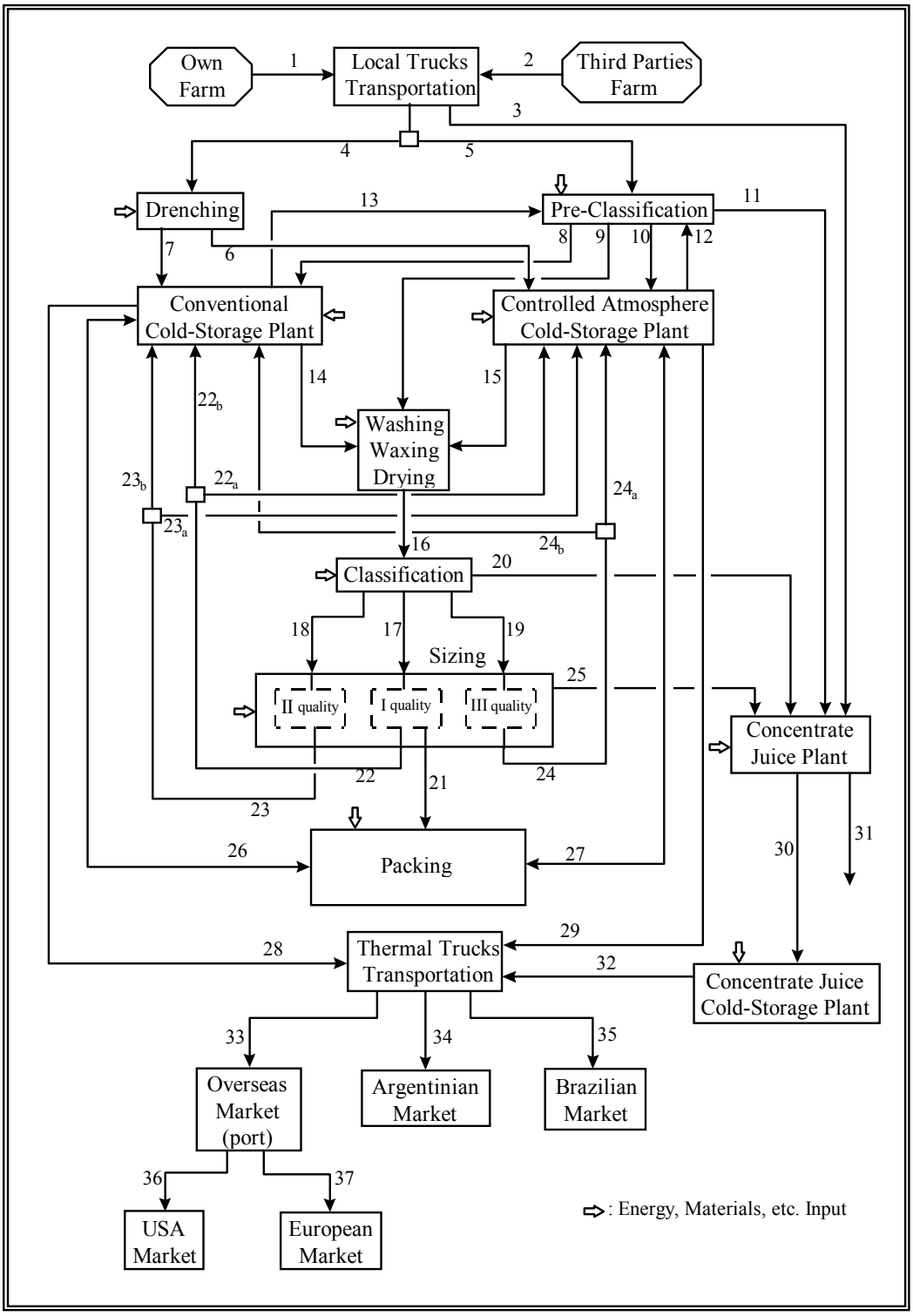
Description of the Lines in the Figure

Comment: the lines in the figure represent the flow of the five varieties of fruit in the different harvest times (from January until May).

1. Bins from woods with warm fruit (recently harvested) coming from own farms.
2. Bins from woods with warm fruit (recently harvested) coming from third parts farms.
3. Fruit discarded in farms as adequate for the packing process, and transported in bulk to the concentrated juice plant. This fruit is normally from own farms.
4. Bins from woods with warm fruit to the previous washing process, or drenching, before going to the refrigeration stage.
5. Bins from woods with warm fruit to the pre-classification process.
6. Bins with pre-washed fruit to CAC.
7. Bins with pre-washed fruit to CC.
8. Bins of pre-classified fruit to CC.
9. Pre-classified fruit to the washing, waxing and wax drying process.
10. Bins of pre-classified fruit to CAC.
11. Fruit discarded because sanitary quality defects going to the juice production plant.

12. Bins with pre-washed fruit (corresponding to the incoming line 6) going from the CAC to the pre-classification process.
13. Bins with pre-washed fruit (corresponding to the incoming line 7) going from the CC to the pre-classification process.
14. Bins with pre-classified fruit (corresponding to the incoming line 8) going to washing and waxing process.
15. Bins with pre-classified fruit (corresponding to the incoming line 10) going to the washing and waxing process.
16. Fruit going to the classification.
17. Fruit classified as Sanitary Quality I going to the sizing machine.
18. Fruit classified as Sanitary Quality II going to the sizing machine.
19. Fruit classified as Sanitary Quality III going to the sizing machine.
20. Fruit discarded because of sanitary quality defects going to the concentrated juice plant.
21. Fruit of Sanitary Quality I and selected sizes for exportation to overseas markets, going to the packing machine.
22. Fruit of Sanitary Quality I and selected sizes for exportation to the regional (Brazilian) market going to cooling in the CAC (line 22a) and in the CC (line 22b).
23. Fruit of Sanitary Quality II and selected sizes for exportation to the regional (Brazilian) and domestic (Argentinean) markets going to cooling in the CAC (line 23a) and in the CC (line 23b).
24. Fruit of Sanitary Quality III of selected sizes for exportation to the regional (Brazilian) and the domestic (Argentinean) markets going to cooling in the CAC (line 24a) and in the CC (line 24b).
25. Fruit discarded because sizes out of specified ranges going to the concentrated juice plant.
26. Packed fruit (of all qualities and selected sizes) going to the CC, and in the contrary sense, selected fruit (quality and size) conserved in the same chamber going to the packing machine.
27. Packed fruit (of all qualities and selected sizes) going to the CAC, in the contrary sense, selected fruit (quality and size) conserved in the same chamber going to the packing machine.
28. Pallets of fruit packed and cooled in CC (of all the qualities and selected sizes) going to refrigerated or “thermal” trucks to be transported to the different markets.
29. Pallets of fruit packed and cooled in CAC (of all the qualities and selected sizes) going refrigerated or “thermal” trucks to be transported to the different markets.
30. Concentrated juice of pears and apples (packed in plastic drums or triple coated plastic bags placed in special bins) going to juice cold-storage plant.
31. Lost fruit in the concentrate juice production process.

32. Concentrated juice (packed in plastic drums or triple coated plastic bags placed in special bins) and cooled going to the thermal truck of transportation to the different markets.
33. Fruit shipment to load in the port.
34. Fruit shipment transported by refrigerated trucks to the domestic (Argentinean) market.
35. Fruit shipment transported by refrigerated trucks to the regional (Brazilian) market.
36. Fruit shipment transported by ship to the USA market.
37. Fruit shipment transported by ship to the European market.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