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PERISHABLE FOODSTUFFS WITHIN THE SYSTEM OF SUPPLY LOGISTICS

ABSTRACT

Manufacturers and traders have always had to handle the management of supply chains. However, this concept in its present meaning has only gained major importance in the recent years. This is the result of linking supply chains with new technologies. The supply chain starts and ends with the end buyer. The essence of supply chain management is awareness of the buyer's wishes and rapid delivery of the required products or services. Supply chains play an exceptionally important role today. A common strategy for joint projects has to be worked out with partners. In order to achieve this, a high degree of trust must exist between them. Partners from various disciplines are not competitors, but complement, and co-operate with each other. In cold chains that ensure that perishable goods cover the producer-consumer route in the shortest possible time, co-operation and trust are of key importance since only companies able to provide the buyer with the right product at the right place and at the right price are successful in the market.

KEY WORDS

perishable foodstuffs, transportation, supply chains management, cold chain, logistics

1. INTRODUCTION

Manufacturers and traders have always had to handle the management of supply chains, however this concept in its present meaning has only gained major importance in the recent years. This is the result of linking supply chains with new technologies. The supply chain starts and ends with the end buyer. The essence of supply chain management is awareness of the buyer's wishes and rapid delivery of the required products or services.

Supply chains play an exceptionally important role today. A common strategy for joint projects has to be worked out with partners. In order to achieve this, a high degree of trust must exist between them. Partners from various disciplines are not competitors, but complement, and co-operate with each other. In cold chains that ensure that perishable goods cover the producer-consumer route in the shortest possible time, co-operation and trust are of key importance, since only companies able to provide the buyer with the right product at the right place and at the right price are successful in the market.

Modern consumer's society depends on efficiency of supply chains. The main aim of supply chains is to offer diversity of products on the market at the right place at the right price, at the right time. In this work, which is quite complex and multidisciplinary, we presume the following hypothesis: "*Effectiveness, contentedness and efficiency of modern society are significantly dependent on efficiently organized and managed different supply chains. In the system of assurance of perishable foodstuffs the cold chain plays an important role.*"

The main aim of the work is to ascertain degree of connectedness between the management of supply chains and different areas of supply logistics. Special attention is paid to management of special kinds of supply chains, designed for management of perishable foodstuffs.

In order to prove the hypothesis, methods of analysis, synthesis and the inductive and deductive scientific methods are used. The theory of systems as a method is the most important scientific method used in this work because it enables qualitative, structural, and functional analysis of models.

2. WORLD TRADE

In the recent years annual trade has hovered around € 50 billion in value and 70 million tonnes. In value, on the average, from 1996 – 1998, the US was the world's leading exporter with a share of 18%, followed by the EU with 12%, China 7%, Mexico 7% and Turkey 5%. Over the same period, the leading importer was the EU with 27% of the total, followed by the US (18%), Japan (11%) and Canada (6%).

Two countries had an important trade deficit, the EU (– €9 billion) and Japan (– €5 billion), while surpluses were registered mainly in China (+ €3 billion),

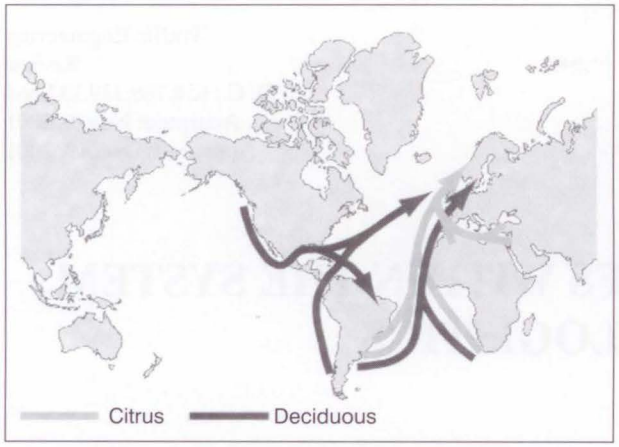

Figure 1 - Main perishable cargo flows in the Atlantic Area

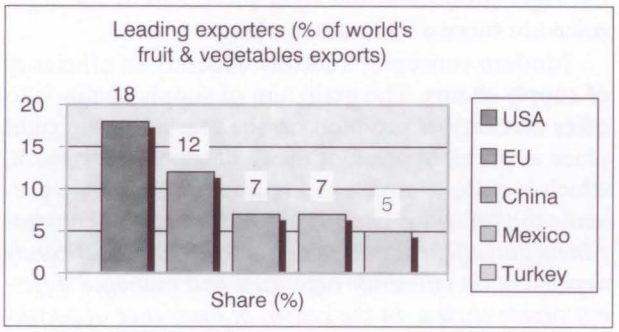

Figure 2 - Leading exporting countries

Mexico (+ €2.5 billion) and Turkey (+ €2 billion). As the top net importer, the EU is the largest solvent market.

The products most traded worldwide were citrus fruit with 4.4 million tonnes or €2.6 billion, apples 3.2 million tonnes or €2.1 billion), onions (3 million tonnes or €1 billion) and tomatoes (2 million tonnes or €1.6 billion).

2.1. World's supply and demand[1]

On the average, between 1998-1999 the world production of fruit and vegetables was slightly more than 1,100 million tonnes: fruit amounted to 530 million tonnes and vegetables to 470 million tonnes. Asia is the leading production region with a share of nearly 56% followed by Latin America & the Caribbean 12%, the EU 10%, Africa 9% and North America 7%. The world's largest fruit and vegetables producer overall is China (29%), then the EU (10%), India (10%) and the US (7%).

The world consumption for the same period (960 million tonnes) was more or less 180 million tonnes lower than the production. Again Asia is the leading region with 59% of the total, followed by the EU (10%), Africa (9%), North America (8%) and Latin America & The Caribbean (8%). The world's top consumer is China with a share of 30% followed by India and the EU (10%) and the US (7%).

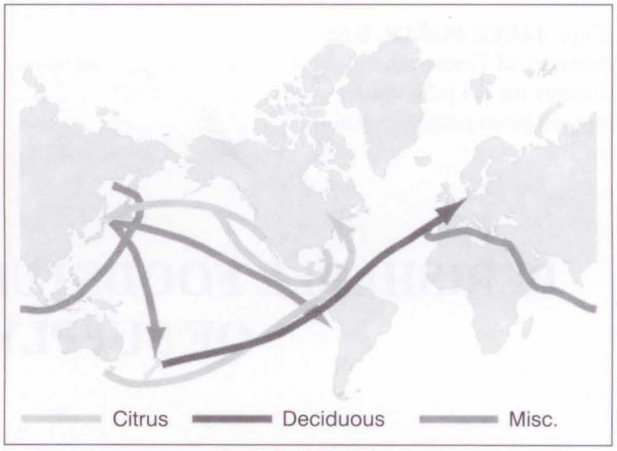

Figure 3 - Main perishable cargo flows in the Pacific Area

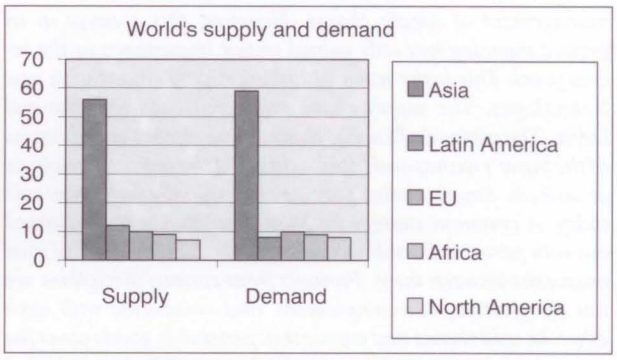

Figure 4 - World's supply and demand

At the world level there is a strong trend towards increased production, with consumption increasing at a slower pace. In some developing countries most production growth potential seems oriented towards increased domestic consumption, while in others export oriented production is being developed.

2.2. Supply and demand in the EU[2]

Over the last years, EU-15[3] total vegetable production represented about 55 million tonnes; the leading member state was Italy with 15 million tonnes followed by Spain with 11.5 million tonnes. EU-15 total fresh fruit production was slightly over 30 million tonnes, of which 9 million tonnes were citrus fruit. Spain was the leading member state with 10 million tonnes of which 5.5 million tonnes was citrus fruit.

Early in the 80's EU vegetable production was around 45 million tonnes, nearly 20% lower than today; for total fresh fruit including citrus the figure was 27 million tonnes or 12% less than today.

On the demand side, the trend of EU consumption is stable for fresh fruit and vegetables with 29 million tonnes and 41 million tonnes respectively, equivalent

to a per capita consumption of 92 kg and 133 kg. By contrast, consumption of processed fruit, mainly fruit juice, shows a sharp upward trend.

2.3. Fresh fruit and vegetable market organization in EU

In July 1994 the European Commission presented to the Council and the Parliament its communication on the development and future of Community policy in the fruit and vegetable sector. In the Commission's view the main objective was to help and encourage EU producers to meet the challenges of a more open and competitive market by strengthening their assets, namely:

- the quality of their products;
- their dynamism and ability to adapt to a changing market;
- services offered alongside the supply of a range of varied and healthy products.

After two years of discussion in the Council, regulation for fresh fruit and vegetables, citrus and processed fruits and vegetables were finally adopted on 28 October 1996.

On 12 July 2000 the European Commission adopted a proposal to amend the common organization of the market for fruit and vegetables. This proposal was aimed at providing solutions to shortcomings that had to be addressed urgently.

3. INTRODUCTION TO SUPPLY CHAINS

The supply chain is so broad and that is why people have such complicated definitions. The supply chain is from dirt to dirt. It starts out with obtaining the initial raw material from earth and goes until the product is recycled back into the earth.

While "supply-chain" and "demand-chain" are phrases often used to describe parts of materials management, the true nature of the "chain" metaphor is almost always glossed over. Often, things are related to one another without forming an interlocking chain and this point is frequently missed in supply-chain references. The most common definition of supply-chain is done at a perspective that is outside of one company. The phrase "a company's supply-chain" doesn't even make sense according to these omnipotent perspectives that define the term.

Figure 5 below shows a common view of a supply-chain.

Supply chain is typically viewed as a set of value-adding cells extending from the suppliers to the customers. There are two key flows across these cells. First, the upstream flow of customer orders. Second, as a reaction to or in anticipation of customer orders, the downstream flow of products or material.

Each node on the network is viewed as a value-adding cell with a clearly defined set of input and an identifiable customer. While correct in theory, this definition is too restrictive for practical purposes. It assumes that a network can be cut up into individual cells and analyzed in isolation.

For the companies that have made a mission of distributing perishable foodstuffs, the world has become a single market and the system called "*Cold chain*". Without it, perishables would spoil long before reaching their destination and with them considerable expense and effort would be lost. But it is difficult to maintain the "Cold chain" because of its complexity. Through the efforts of many players on several conti-

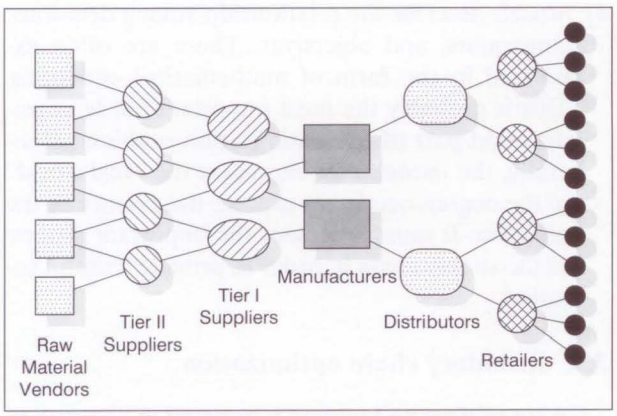

Figure 5 - Typical supply - chain definition diagram

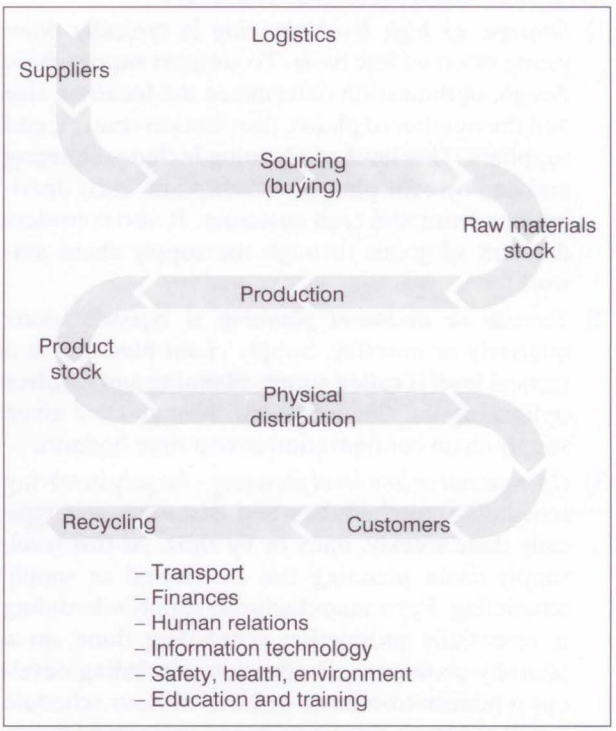

Figure 6 - The logistics supply chain

nents the chain has been made stronger and its weak links easier to spot.

One key principle of the supply chain management is to define and apply a set of global performance measures, which will effectively keep all the trading partners in alignment with the operational goals of the enterprise-wide supply chain[4]

Trading partners can be organized into a supply chain using one of three basic architectures:

1) *Traditional indirect channel* provides good market reach and customer service at the expense of high inventory levels and thin margins.
2) *Traditional direct channel* approach provides good margins with lower inventory levels, but with longer order fulfilment times depending upon geography.
3) The recent explosion of the Internet and growing acceptance of secure e-commerce now makes a third supply chain architecture practical. *The virtual channel* provides the convenience of shopping from home via the Internet and a high return on assets with more difficult inventory control and medium margins.

None of these three approaches is perfect. Each involves tradeoffs among strategic supply chain decision factors.

3.1. Planning processes

Currently, supply chain planning is usually done using three hierarchical planning levels:

1) *Strategic or high level planning* is typically done yearly or on ad hoc basis. To support supply chain design, optimization determines the location, size and the number of plants, distribution centres, and suppliers. This level of planning includes sourcing and deployment plans for each plant, each distribution centre and each customer. It also considers the flow of goods through the supply chain network.
2) *Tactical or mid-level planning* is typically done quarterly or monthly. Supply chain planning at a tactical level is called supply planning and involves optimizing the flow of goods throughout a given supply chain configuration over a time horizon.
3) *Operational or low-level planning* – largely involving scheduling, rescheduling and execution – is typically done weekly, daily or by shift. At this level, supply chain planning can be viewed as supply scheduling. For a manufacturer, supply scheduling is essentially production scheduling done on a plant-by-plant basis. Production scheduling develops a minute-to-minute or hour-to-hour schedule for all of plant's resources needs, including labour, equipment and materials.

3.2. Supply chain optimization

Optimization problems seek a solution where decision need to be made in a constrained or limited resource environment. Most supply chain optimization problems require matching demand and supply when one, the other, or both may be limited. By and large, the most important limited resource is the time needed to procure, make, or deliver something. Since the rate of procurement, production, distribution, and transportation resources is limited, demand cannot be instantaneously satisfied. It always takes some amount of time to satisfy demand, and this may not be quick enough unless supply is developed well in advance of demand. In addition to time, other resources, such as warehouse storage space or truck's capacity, may be constrained in meeting demand. An optimization problem comprises four major components:

1) *Decision variables* are within planner's span of control:
   a) when and how much of a raw material to order from a supplier;
   b) when to manufacture an order;
   c) when and how much of the product to ship to a customer or distribution centre.
2) *Constraints* are limitations placed upon the supply chain:
   a) a supplier's capacity to produce raw materials or components;
   b) a production line that can only run for a specified number of hours per day and a worker that must only work so much overtime;
   c) a customer's or distribution centre's capacity to handle and process receipts.
3) *Objectives*: maximize, minimize, or satisfy something, such as the following:
   a) maximizing profits or margins, customer service and production throughput;
   b) minimizing supply chain costs or cycle times, lateness, etc.;
   c) satisfying all customer demands.
4) *Models* describe the relationship among decisions, constraints, and objectives. These are often expressed in the form of mathematical equations. This is probably the most important but least understood part of the optimization problem. Generally, the model must represent the "real world" to the degree needed to capture the essence of the problem. It must represent the important aspects of the supply chain in order to provide a useful solution.

3.3. Inventory chain optimization

A lot of time and money is invested in a variety of technologies to increase corporate return of invest-

ments. These systems have enabled management to make better and timelier decisions in inventory levels. The ability to quickly reduce such inventories gives management a great opportunity to quickly increase ROI.

In supply chain management, specific policies and procedures are implemented to manage inventories at specific locations (links) in the chain. Depending on where inventories are located in the chain, inventory is classified as either supply or demand. The key optimizing supply chain management is to both optimize the information flow across the chain and optimize the total inventory in the supply chain to meet customer service level goals.

Because the supply chain is made of one or more links, the products flow only one way through the links from the sources of raw materials to finished goods for the customers. The demand and supply transaction information flowing both ways, back and forth, between customers, distributors, manufacturing raw material sources etc, control the product flow. Therefore, a supply chain actually consists of two fundamental and functional flows:

1) the flow of transaction information, and
2) the flow of material and products.

Because of its complexity, inventory management in cold chains is very hard and unpredictable.

4. COLD CHAINS

The consistent management of temperature during the supply chain is the key to the delivery of high quality perishable products to the consumer. Key issues for customizing the cold chain are: cold chain integrity, knowledge of one's own supply chain, food safety, temperature monitoring and product specifications and handling. Also, quality of the cold chain depends on the breaks in it. Product quality is impacted by breaks in the cold chain, in particular because of the number of breaks, length of it, and exposure to temperature and recovery ability of the product.

4.1. Importance of the cold chain

As the market for refrigerated products and prepared meals is increasing rapidly, shelf life of fresh products is extended, whereas thermal treatments of products and ingredients are reduced to meet the consumer demand for fresh nutritious and tasty foods. Meanwhile, consumers and public authorities expect a high level of safety from foods throughout the cold chain.

Europe and most countries have set up regulations for temperature control and equipment performance evaluation for different steps of the cold chain from the storage down to display cabinets. When determining the shelf life of a product, the most difficult point is to take into account the life of the product after the purchase by the consumer.

Risk assessment is necessary and will require methodologies to evaluate the influence of the different steps of the cold chain, from the production down to the refrigerator of the consumer, at the risk of developing pathogenic bacteria in the refrigerated products.

4.2. Refrigerated foods and food safety and quality[5]

Majority of foods consumed in developed countries are sold chilled or frozen. *Alcaligenes* species, *Flavobacte-rium, Microbacterium, Xanthomonas, Brochotrix Thermosphacta, Lactobacillus, Pseudo-monas*, but also yeast and molds etc. could grow during the extended refrigerated storage or temperature abuse.

Temperature fluctuations may also result in the loss of quality of frozen products.

4.3. Temperature control and equipment performance

Since temperature abuse in the cold chain can cause microbial hazards and loss of product quality and nutrients, temperature control is essential to keep products safe. Public authorities in many countries have established food safety regulations generally including different kinds of requirements:

- limits for product temperature in the cold chain,
- obligatory recording of air temperature in refrigerated vehicles or storage rooms,
- conformity of equipment to standards, and assessment of conformity through laboratory testing.

Regulations and food control systems differ from country to country. European regulations and directives have been harmonized for temperature of frozen products and most steps of the production and distribution chain.

4.4. Temperature limits and temperature recording

Maximum temperatures have been fixed in the European directives concerning meat and animal products.

The European Community directive EN 92/1 CEE has made air temperature recording obligatory during transportation of frozen foods. Thermometers are obligatory in display cabinets and storage rooms. Three main steps of the cold chain are covered by regulations: transportation, storage and retail display.

– *Transportation*

Improving the conditions of preservation of the quality of perishable foodstuffs during their carriage, particularly in international trade is in the scope of the "Agreement on the international carriage of perishable foodstuffs and on the special equipment to be used for such carriage" (ATP), established in 1970, by which contracting parties take the measures necessary to ensure that equipment used for carriage of perishable foodstuffs complies with technical standards defined in the Agreement. Independent laboratory testing assesses conformity to these standards. The standards defined by ATP include limits in heat loss of insulated bodies (W/m^2K) and ratio between the effective refrigerating capacity of the refrigerating unit and the heat loss of the body.

– *Storage and retail display*

The second and third important steps of the cold chain are storage and retail display before delivery to the consumer. Temperature limits also apply to these steps. For display cabinets, standards have been adopted internationally. However, their application is not compulsory.

4.5. Temperature traceability and product temperature prediction

The distribution chain of food products is generally composed of many different steps of storage and transportation until consumption. Product temperature may vary in each step, especially when loading and unloading is performed outside controlled temperature conditions, and after the sale to the consumer.

The concept of "cold traceability" has been proposed and existing tools include thermometers, temperature recorders, temperature indicators and TTI (time temperature integrators). These tools make it possible to have better knowledge of time – temperature in the cold chain.

Air temperature recording is available in many steps of transportation and storage performed by industrial companies. However temperature history of the product from production to distribution is difficult to determine for different reasons:

- Recorded temperatures are generally air temperature and differ from product temperatures. Causes of temperature variations and dispersion have been discussed and result from products stacking on pallets where refrigeration is far from homogeneous;
- Product life after retail to consumers depends on individual behaviour of consumers towards food safety. Because risk assessment needs to consider the whole life of the product, including the step after sale to consumer, i.e. transportation and storage in home refrigerator where temperature recording is generally not available, reliable information has to be obtained through statistical assessment of consumer behaviour. So far such information has been rare.

5. LEGAL ISSUES

– *ATP Agreement*[6]

The agreement on international transportation of perishable foods and on the special means of transportation to be used for this kind of traffic lays down a set of rules and standards that are to be applied in the international transportation of certain perishable foods.

If the requirements of the ATP are not met, the food being transported (specifically frozen or deep-frozen foods as well as butter, game, poultry, fish) may have to undergo special checking.

The main requirements of the ATP are with respect to technical details of the means of transportation (lorries/trucks, trailers, containers, wagons/freight cars and other similar means of transportation) and test requirement to check for these standards. For that purpose, the means of transportation are divided into classes that have an additional two or three capital letters for further distinction. They specify:

- whether there is any means of cooling,
- whether there is a refrigerator or an ice bunker,
- whether there is a simple or a reinforced insulation,
- and for what temperatures the means of transportation is suitable.

Unit assesses conformity to the requirements of the ATP or by type testing and the results are recorded in a test report. These tests must be repeated in predefined intervals.

The classification and the expiry date have to be written on the outside of the vehicle in dark blue letters. They have to be wiped out if the requirements of the ATP are not met any more.

– *The Codex Alimentarius*

The Codex Alimentarius, or the food code, has become the seminal global reference point for consumers, food producers and processors, national food control agencies and the international food trade. The code has had an enormous impact on the thinking of food producers and processors as well as on the awareness of the end users - the consumers. Its influence extends to every continent, and its contribution to the protection of public health and fair practices in the food trade is immeasurable.

The Codex Alimentarius system represents a unique opportunity for countries to join the international community in formulating and harmonizing

food standards and ensuring their global implementation.

The Codex Alimentarius has relevance to the international food trade. With respect to the ever-increasing global market, in particular, the advantages of having universally uniform food standards for the protection of consumers are self-evident. As such, Codex standards have become the benchmarks against which national food measures and regulations are evaluated within the legal parameters of the Uruguay Round Agreements.

– *EU Regulations*

Three regulations were adopted, and major amendments were recently made to all the three by Regulation (EC) No. 2699/2000. Those Regulations are:

- *Council Regulation (EC) No. 2200/96 on the common organization of the market in fruit and vegetables*. For fruit and vegetables, this regulation reflects the general objectives
  - By strengthening the role of producer organizations;
  - By amending the way of administering short-term surpluses in order to reduce the risk of structural surpluses.
- *Council Regulation (EC) No. 2201/96 on the common organization of the markets in processed fruit and vegetable products.*
- *Council Regulation (EC) No. 2202/96 introducing a Community aid scheme for producers of certain citrus fruits.*

6. MANAGING PERISHABLE PRODUCTS

Many companies have found that supply chain management initiatives have greatly increased their profitability, reduced inventory, and improved their ability to match supply with demand. But perishable products are the cutting-edge challenge in supply chain management. Complex, long-term forecasts may have little meaning, while even the conventional wisdom of experienced retailers may have limited relevance in a unique and rapidly changing market environment.

The challenge in managing supply chains for perishable products is to ensure product availability while keeping the product obsolescence low. The ability to respond to market signals as well as the ability to develop accurate demand forecasts and update them based on recent information is critical.

Supply chain management for perishable products is more challenging than supply chain management for functional[7] products for three reasons:

1) The *demand pattern* for these products makes estimation of demand and demand variability extremely difficult. Understandably, it is harder to predict demand for these products.
2) Traditional *forecast methods* usually assume at least one year of demand history is available, which is not possible for perishable products since they generally have a life cycle that is less than one year.
3) The *cost of carrying inventory* is much higher for perishable products because of the risk of obsolescence.

This necessitates inventory-planning algorithms that are more precise than those that had been developed.

6.1. Perishable goods

There is a wide variety of cargoes transported in refrigerated containers, all requiring unique temperature settings. These cargoes commonly range from ice cream, requiring a temperature setting of approximately –25°C, to flower bulbs requiring a temperature setting of up to +30°C, with many cargoes in between.

Refrigerated cargoes are transported all over the world, travelling through climates as hot as the torrid summers of the Persian Gulf and as cold as the frigid winters of the Antarctic Ocean. The combination of the cargo temperature requirements and the climatic variations means correct temperature control of the refrigeration unit is essential, ensuring the cargo reaches its final destination in the desired condition. An extensive knowledge and expertise in the carriage of temperature - controlled cargoes is definitely needed. Cargoes should be transported efficiently and effectively from the point of loading all the way through to the final destination, ensuring they arrive in pristine condition for the final customer.

– *Frozen cargoes*

Freezing is a very popular form of food preservation and products are regularly carried by reefer transport. The cargo is put into a state of suspended animation, enabling it to be utilized weeks or even months after production. The frozen state prevents the growth of bacteria, slowing enzyme activity and oxidation; thus extending its storage period.

– *Frozen meats*

Most frozen meat cargoes consist of prepared cuts, in accordance with customer or national preferences. National regulations for the import and export of meat cargoes can vary from country to country, and frequently the maximum storage temperature is specified. Commonly this is –12°C, but it can vary to –18°C.

– *Frozen poultry*

When transporting poultry, special attention must be paid to oxidative rancidity and freezer burn (dehydration) prevention. Carriage must be at –18°C or colder, preventing bacteria multiplying, and maintaining storage life.

– *Frozen fish*

Frozen fish and seafood storage life is very temperature dependent. Under normal conditions, storage life triples for every 10°C colder the storage temperature is, with fatty fish having a shorter storage life than white, leaner fish. Regulations for storage temperatures for frozen fish and seafood are becoming more common. A general rule is to store and transport these cargoes as cold as practically possible for the product, with careful handling minimizing temperature fluctuations after freezing.

– *Frozen fruits and vegetables*

Frozen vegetables are often blanched in hot water or steam before freezing, killing most bacteria and reducing enzyme activity. The practical storage life of vegetables can be extended if they are packaged in materials impermeable to moisture loss and stored at temperatures colder than –18°C, barring temperature fluctuations.

Frozen fruit is not usually blanched in hot water or steam. Careful selection is important to ensure that only high quality materials are frozen, as even good packaging and low temperatures will not prevent very low levels of enzyme activity.

– *Frozen confectionery*

The most sensitive item in the container governs the storage life of a cargo of frozen confectionery. Items have different storage characteristics, and packaging plays an important role in minimizing rancidity and providing physical protection to fairly fragile items. The general rule is the colder the temperature the better the quality at result.

– *Ice cream*

Due to the pasteurization process during manufacturing, ice cream is one of the safest products on the market, provided that good hygiene, temperatures and package integrity is maintained.

– *Dairy products*

Frozen butter is usually a large volume commodity. In practice set point temperatures are usually –14°C or colder, although some cargoes can be carried at warmer temperatures. Long-life hard cheese is normally carried with set points between +1°C and +7°C depending on the type of cheese, packaging, length of transit and the intended use.

– *Temperature controlled fruits and vegetables*

Careful planning is required when transporting fruit and vegetables[8], the carriage conditions vary from cargo to cargo and season to season. Many countries have specific standards that must be adhered to, for example; the quality of the product, labelling on the packages and proof that fruit fly has been killed in transit.

The successful carriage of fruit and vegetables begins with the harvest, which must occur under optimal maturity conditions. During the post-harvest process, the sorting, trimming and washing of the crop must be performed with absolute care. Following this, cooling is nearly always required; this slows the ripening process to a minimum. Correct packaging using bags, cartons or trays is necessary to protect the cargo; packing must be performed quickly to keep the product cool.

Fruit and vegetables are actually live products that respire, their cells are metabolizing, constantly consuming oxygen and carbohydrate and producing water vapor and carbon dioxide. A small amount of ethylene gas, a ripening plant hormone, may also be produced.

Ethylene is an essential hormone for the ripening process; not only does it increase the ripening speed, it can also ensure an improved uniformity of the ripening process. Unfortunately there are numerous undesirable effects of ethylene:

- Accelerated ripening and softening of fruits during storage when not desired;
- Accelerated senescence and loss of green colour in some immature fruits (cucumber, squash, etc.) and leafy vegetables;
- Russet spotting on lettuce;
- Sprouting of potatoes - either stimulation or retardation, depending on the concentration and duration of exposure to ethylene;
- Toughening of asparagus.

It is not only ethylene gas that needs to be controlled to prevent damage occurring to cargoes. Carbon dioxide build-up can result in tissue damage; water vapour produced can encourage the development of mould, rot and fungi; and the heat produced by the 'breathing' of the cargo can also damage it.

Undesirable effects of carbon dioxide, ethylene, heat and water vapour[9] can be controlled in a number of ways. Good stowage of the cargo results in better air circulation in the container, which in turn reduces the build up of gases, heat and water vapour.

Temperature controlled fruits and vegetables require much care and attention throughout the transport process.

– *Sensitive temperature controlled cargoes*

Sensitive temperature controlled cargoes are defined as those cargoes that must be transported at a temperature within 1°C of their freezing or damage

point. Meat products account for much of business in this area, other cargoes include root vegetables, i.e. carrots and parsnips, and some fruits, such as avocado, oranges, bananas and some live plants.

– *Live plants*

The transportation of live plants in temperature-controlled containers has led to a dramatic increase in their shipments. Temperature controlled containers enable the plants to be transported over greater distances and longer transit periods, through the improved care during the shipment. As with the transportation of chilled fruit and vegetables, a very significant part of the transportation of live plants is the pre-carriage care and preparation.

– *Flower bulbs*

The term flower bulb, in general, covers a wide range of bulbous plants of which the most commonly exported species are tulips, daffodils and hyacinths. Each consignment of flower bulbs has its own unique storage and transport temperature requirements, which should not deviate by more than 1°C warmer or colder.

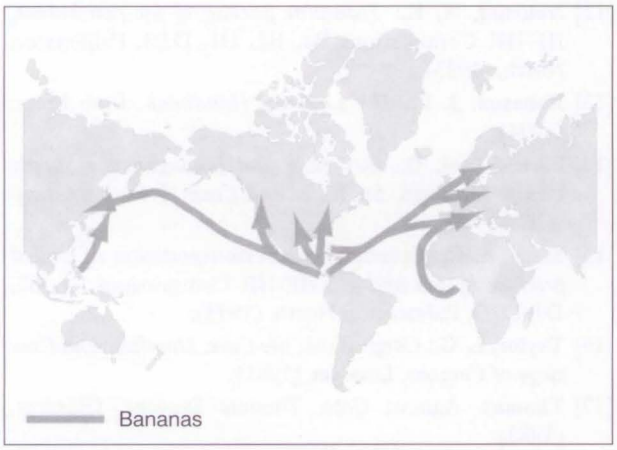

Figure 7 - Bananas trading flows

– *Other temperature-controlled cargoes*

Such cargoes include films, pharmaceuticals, and most foodstuffs that need to avoid condensation and staleness. The diversity of these cargoes is reflected in their set point temperatures, which range from –2°C to +30°C. They need to be pre-cooled to their transport temperatures before loading, and are usually blocked stowed in the container, as they do not generate heat[10].

7. CONCLUSION

Supply logistics, especially when the cold chain is in question, plays one of the most important roles in today's global economy.

We should summarize the importance of managing of perishable foodstuffs within the supply logistics as follows:

- The cold chain logistics is complex and needs to be well understood by all parties involved in it;
- Everybody in the cold chain needs to know what happens along the chain, not only in his link;
- Planning to ensure optimum out-turn of product by knowing how product is going to be handled and where cold chain breaks occur;
- Knowing customer's needs;
- Poor cold chain links can seriously damage cold chain integrity.

Also, Cold chain management is an important activity that forms part of the distribution services. It involves the transportation of pharmaceuticals, food articles, perishable foodstuffs and other time and temperature sensitive items, under temperature control in different transport modes. Also, transportation modes can be further divided into different temperature zones, depending on the needs of customers.

Perishable goods, too, play an exceptionally important role in providing the population with a healthy way of life – the fresher and healthier the food, the fewer ailments and lower the relevant costs. And this is the essential purpose of cold chains – to provide the end buyer with healthy and quality products.

Transportation of perishable foodstuffs is covered by special legislation (ATP Agreement, Codex Alimentarius and various European or national legislations), its organizational level is much more complex than others, and finally, it needs specific infrastructure (special transportation devices, equipment, stores etc.).

We can conclude, that models of cold chains that are implemented on the large, global systems could also be implemented on small, limited systems (supply of a small, national market, like Slovenia, for example).

According to the complexity of the cold chains, specific infrastructure and transportation devices and special legal issues can be concluded, that scientific hypothesis is proven.

POVZETEK

Oskrbne verige igrajo v današnji sodobni potrošniški družbi izjemno pomembno vlogo. Praktično vse veje gospodarstva so del nekakšne oskrbne verige, pa naj bo to avtomobilska industrija, predelovalna, železarska, prehrambena in podobno. Znotraj samih oskrbnih verig pa najdemo posebno vrsto oskrbnih verig, ki so namenjene oskrbi tržišča s hitro pokvarljivim blagom, katere imenujemo hladne verige. Hladne verige so izjemno specifične, tako zaradi samega rokovanja s produkti, s katerimi rokujejo, kakor tudi zaradi posebne infrastrukture, ki jih za nemoteno delovanje potrebujejo, in končno tudi posebnih predpisov, ki to področje urejajo. Posebna pozornost v

hladnih verigah je vsekakor namenjena pravilnemu rokovanju s produkti, saj se lahko že ob najmanjšem odstopanju od zahtev pojavijo nepopravljive škode z velikimi finančnimi posledicami. Poseben problem hladnih verig predstavlja tudi upravljanje zalog, saj je napovedovanje potreb izjemno nepredvidljivo in zahteva posebna znanja in veščine. V sklepni fazi hladnih oskrbnih verig pa lahko ugotovimo tudi pozitivne socialne posledice le-teh, saj je splošna oskrba prebivalstva z visoko kvalitetnimi produkti ključnega pomena za njegovo zdravje.

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5. International Institute of Refrigeration: »Guide to refrigerated transport«, Paris, 1995.
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7. See **M. L. Fisher**, *»What is the right supply chain for your product?«*, Harvard Business Review, March-April 1997.
8. Condensation occurs when moisture-laden air releases its water vapor on to the surrounding surfaces in the form of water droplets. For condensation to occur the following conditions need to be present:
   - Temperature gradient (Between air inside and outside the container)
   - A source of water vapor (moisture).
   - Pathway for it to move.
9. Saturated Air - for a given atmospheric pressure, air holds more water vapour at higher than lower temperatures. The maximum amount of water vapour contained in a cubic meter of saturated air decreases with a decrease in temperature. At 40°C it can contain 51 grams, at 20°C 17 grams and at 0°C only 5 grams.
10. Cargo sweat occurs when the surface of the cargo is cooler than the dew point of the air enclosed within the container. Droplets of water then form on the surface of the cargo.

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