# Present State of Cold Chain and Postharvest Loss of Fruits and Vegetables in Croatia and Serbia

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## Summary

To elucidate key factors responsible for high postharvest loss, an analysis of the cold chain systems in Croatia and Serbia was made. It is estimated that Western Balkan Countries (WBC) annual postharvest loss of fruits and vegetables is as high as 30-40%.

In Croatia there are about 125000 t of storage capacities. Controlled atmosphere (CA) storage comprises only 27% and it is mainly used for apple. Annual apple production in Croatia in 2009 was 93355 t, which means that at least additional 40000 to 50000 t of CA storage is needed only for apple. The second most stored fruit in Croatia is Satsuma mandarin.

Total capacity of refrigerated or frozen storage in Serbia was estimated at 500000 to 600000 t. In Serbia exist 29 CA storage facilities with a capacity between 50000 and 60000 t. Serbia has been very successful in production and export of frozen raspberries and make one-third of the world's total exports. About 97% of Serbia's exports go to the European Union (EU), accounting for 65% of total EU imports of this product.

Beside the lack of adequate storage facilities, the second problem in Croatian and Serbian postharvest sector is the lack of experienced experts familiar with the situation on the domestic market. To improve situation and to decrease high postharvest losses of the fruits and vegetables sector there is an urgent need for establishing long-term network between all segments of this sector together to the more intensive cooperation between WBC in postharvest research.

## Key words

cold chain management, postharvest loss, fruits, vegetables

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## Introduction

Fresh fruits and vegetables contain high water contents and are generally more perishable than other crops after harvest. Approximately one third of all fresh fruits and vegetables is lost before it reaches consumers (Kader, 2005). Some estimates suggest that about 30-40% of fruit and vegetables are lost or abandoned after leaving the farm gate (Salami et al., 2010).

Postharvest losses in fresh fruits and vegetables are estimated 5 to 35% in developed countries and 20 to 50% in developing countries (Kader, 2002).

The magnitude of postharvest losses is largely influenced by the environmental conditions (temperature, relative humidity, gaseous atmosphere) in which they are kept after harvest and also depends on fruit crop. The average strawberry postharvest losses in Kurdistan province in Iran were found to be 28% (Salami et al., 2010). Postharvest loss of nectarines in Croatia caused by fungal pathogens can be as high as 80% (Jemrić et al., 2009). In India, postharvest losses of mango are 29.73% and in banana they are18.31% in co-operative channel to 28.84 in wholesale channel (Murty et al., 2009). Postharvest losses of onion in Serbia can be as high as 30% or more and are caused mostly to sprouting, decay, rooting and weight loss (Ilić et al., 2009a).

Main factors responsible for postharvest loss of fresh fruits and vegetables are mechanical damage, spoilage by fungi, bacteria, insects, and other organisms and physiological deterioration (Kader, 2002; Choudhury, 2006). Physiological disorders occur as a result of mineral deficiency, low or high temperature injury, or undesirable environmental conditions, such as high humidity. Physiological deterioration can also occur spontaneously owing to enzymatic activity, leading to over ripeness and senescence (Kader, 2002; Choudhry, 2006). To reduce these losses, different measures are recommended in the literature, including gentler handling of produce, better conditioning, faster transportation and proper storage (FAO, 1981; Rolle, 2006). Environmentally friendly methods for control of fungal pathogens such as biological control (Wilson and Pusey, 1985) or heat treatments (Jemrić et al., 2011) are developed but not available for full- scale commercial use due to the economical reasons or the lack of knowledge.

Before relaxing quality and size classifications for marketing (EC, 2008), high loss of fruits and vegetables in EU-countries occurred due to the failure to meet cosmetic or quality criteria. Although not necessarily a post-harvest loss, out-grading represents a significant aspect of postharvest loss (Stuart, 2009). Hence, to maintain quality, improve shelf life and extend marketing period of fruits and vegetables, the control of environmental conditions during storage and transportation are prerequisites (Ilić et al., 2009b).

Refrigeration has been the principal known method of successful storage of fresh fruits and vegetables to retain their freshness and flavor. A cold chain is a temperature-controlled supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities which maintain a given temperature range (Ilić and Vukosavljević, 2010).

The cold chain (pre-cooling, cold storage, refrigerated transport, and refrigerated display during marketing) is a requirement for a successful postharvest industry in any country. Major developments have been observed in the last decade in the cold chain industry in the world, including in some developing regions. World total cold chain capacity in the last decade has increased. In the developing world (DW) it more than doubled in India and increased 66% in Brazil, and 20% in China, but still very little or none in many regions of the DW. The increasing capacity is driven by greater reliance on the cold chain to meet growing trade and consumption of better quality perishable foods, needs to meet international standards of quality and food safety, the retail boom and a growing middle class in these countries. In general, the cold chain in the DW is still not developed adequately, and still needs major improvements, with challenges facing the industries (Yahia, 2010).

Rough estimate is that in WBC annual postharvest loss of fruits and vegetables is approximatelly 30 to 40%. However, no detailed studies of postharvest sector in WBC have been made. Therefore, the purpose of this study is to make survey of this sector in Croatia and Serbia and give recommendations for its improvement.

## Production of fruits and vegetables in Croatia and Serbia

According to FAO statistics in 2009, the top five fruits (excluding grape) in Croatia are apple, plum, satsuma mandarin, olive and peaches and nectarines (Table 1). Apples and plums are grown mainly in the continental region, while satsumas and olives are grown on the Adriatic coast. The most of the production of peaches and nectarines is situated also in this region. Around big cities production of strawberries is well developed. In 2009, Croatia produced 2548 t of this crop (FAO, 2011).

According to FAO statistics in 2009, the top five fruits (excluding grape) in Serbia are plums apples, raspberries, peaches, and nectarines, and pears (Table 1). The production of fruits in Serbia is much higher than in Croatia due to the higher production area. The orders of top five fruits produced in two countries are different and there are also some exceptions (Table 1). Satsumas and olives are produced only in Croatia due to favorable climatic conditions. The most produced fruit in Serbia is plum (Table 1) due to the strong tradition and higher area under cultivation. Serbia has been very successful in production and export of frozen raspberries (more of 100 000 t) and makes one-third

**Table 1.** Top five fruit crops in Croatia and Serbia in 2009 (FAOSTAT, 2011)

| Rank | Crop | Production (t) |
|---|---|---|
| | Croatia | |
| 1 | Apples | 93,355 |
| 2 | Plums and sloes | 38,369 |
| 3 | Tangerines, mandarins, clementines | 37,500 |
| 4 | Olives | 32,592 |
| 5 | Peaches and nectarines | 10,110 |
| | Serbia | |
| 1 | Plums and sloes | 662,631 |
| 2 | Apples | 281,868 |
| 3 | Raspberies | 86,971 |
| 4 | Peaches and nectarines | 77,230 |
| 5 | Pears | 67,771 |

Grape is excluded from statistic since the most of this crop are wine cultivars

**Table 2.** Top five vegetable crops in Croatia and Serbia in 2009 (FAOSTAT, 2011)

| Rank | Crop | Production (t) |
|---|---|---|
| | Croatia | |
| 1 | Potatoes | 270,251 |
| 2 | Cabbages and other brassicas | 66,833 |
| 3 | Watermelons | 44,175 |
| 4 | Tomatoes | 37,419 |
| 5 | Chillies and peppers, green | 35,991 |
| | Serbia | |
| 1 | Potatoes | 898,282 |
| 2 | Cabbages and other brassicas | 326,162 |
| 3 | Watermelons | 230,148 |
| 4 | Tomatoes | 189,353 |
| 5 | Chillies and peppers, green | 171,366 |

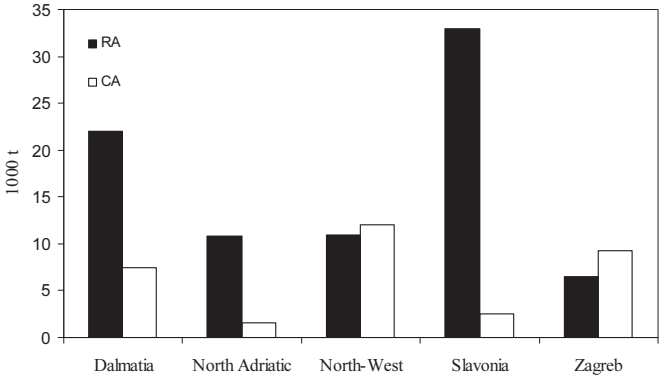


**Figure 1.** Storage capacities in Croatia (author's research)

of the world's total exports. About 97% of Serbia's exports go to the European Union (EU), accounting for 65% of total EU imports of this product.

The combination of agroecological conditions in Croatia enables the almost continuous supply of fresh vegetables, for some species even the whole year without the need of storage. The top five vegetables produced in Croatia and Serbia in 2009 are potato, cabbages and other brassicas, watermelons, chillies and peppers, and onion (Table 2). The order of vegetables produced in Croatia and Serbia is the same, but quantity of production is much higher in Serbia (Table 2).

## Postharvest sector in Croatia and Serbia

It is estimated that in Croatia there are about 125000 t of storage capacities. CA storage comprises only 27% and it is mainly used for apple in Ultra Low Oxygen (ULO) storage regime. Annual apple production in Croatia in 2009 was 93355 t (Table 1), which means that at least additional 40000 to 50000 t of CA storage is needed only for apple. If other fruits, vegetables and other horticultural products are taken into the consideration, the total need for CA storage is much higher. In Slavonia, where the largest apple production is situated, cooling capacities of 33000 t with raw atmosphere (RA) and only 1900 t with a CA are situated (Fig. 1). This creates high risk of postharvest losses caused by the lack of storage or storage in inadequate facilities.

Main postharvest loss of apples is caused by superficial scald and decay. Superficial scald is a serious problem, even in ULO storage as a result of many preharvest factors, inadequate fruit maturity or mistakes made during storage. Postharvest loss of apples caused by superficial scald can be as high as 15% (Jemrić et al., 2006) even in ULO storage. If fruits are harvested too early and stored for too long time period, postharvest loss caused by superficial scald can be as high as 60%. Ethylene inhibitor 1 methylciclopropene (1-MCP) is not registered in Croatia. Alternative anti-scald treatments such as heat treatments (Jemrić et al., 2006), although available, are not adopted in commercial practice. This problem, together with the lack of storage capacity is the main causing factor for postharvest losses of apple.

The second most stored fruit in Croatia is satsuma mandarin. Croatian satsumas mature earlier in comparison to other citrus producing countries and are sold immediately or shortly after harvest. Therefore, it is only for short time in RA (Jemrić and Pavičić, 2004). The main postharvest loss of satsumas is occurred due to the chilling injury and postharvest decay.

Total cold capacity for refrigerated or frozen storage in Serbia was estimated at 500000 to 600000 t. Most of the cold storage facilities are for frozen foods, with temperatures of -20$^0$C (Table 3). Regions such as Arilje, Osečina, Aleksandrovac, and Brus are typical for this kind of storage. Products stored in these facilities are mainly fruit (raspberries, blackberries, sour cherry, strawberries and plums). Raspberry export from Serbia realize quantities about 80000 t per year. More than 80000 farms, 250 cold stores, and 100 processing factories are involved in the berries sector.

Other facilities are ULO cold stores for storing fresh products (mainly apples). In Serbia exist 29 CA storage with a capacity between 50000 - 60000 t (total apple production in Serbia is

**Table 3.** Types, number, size, utilization of capacity and ownership of cold storage facilities in Serbia (author's research)

| Type of facilities | Storage products | Cold storage facilities (number) | Cold storage capacity (t) | Utilization of capacity | Ownership |
|---|---|---|---|---|---|
| Processing facilities with cold storage capacity. | Frozen fruit and vegetables for processing. | 181 | 608,000 | 40-50% | Large, state owned facilities, Private |
| Conventional frozen -20$^0$C | Frozen berries, sour cherry and plums for export | | | | |
| CA - ULO | Apple, pear | 29 | 50-60,000 | 90% | Private, farmer associations |
| Conventional cold storage at 0$^0$C | Carrot, onion, cabbage | 10 | 20,000 | 100% | Private |

240000 tons per year). Export value of Serbian fresh tree fruits per year was around 50 million dollars. All cold stores of this type are new, with very sophisticated technology. Basically, there is nothing to be fixed or invested there, from a structural point of view, although operations and sanitation are lacking.

Attention should be paid to the quality of the fruit for storage, as well as to the duration of storage. Fresh apples should not be sold before May or June, so that the best price, reached at that time of year, can compensate for the investment in CA cold stores. ULO cold stores should be utilized during the summer months, when they are empty, for storing products such as apricots, peaches or plums for a couple of months, for fresh consumption and export. There are relatively few cold storage facilities, with small capacities, for storing fresh vegetables, and they practically do not exist (because potential customers do not see them listed on a registry).

A considerable number of cold storages in Serbia are simple warehouses for storing root vegetables, potatoes, and bulb vegetables, with higher or lower degrees of external influence on the internal warehouse conditions. Thus, the storage period is shortened. These facilities need a considerable amount of assistance. Cold stores' owners sometimes must sell fresh fruits and vegetables before they reach favourable prices, in the late spring (for example, onions in Despotovo). When products are short sold they rarely capture the cost of storage, since the market price is not at its peak. Sometimes cold storage owners are not fruit and vegetables producers, and they do not have technologists who should manage the production and follow the changes during the fresh products storage.

Beside the lack of adequate storage facilities, the second problem in WBC postharvest sector is the lack of experienced experts familiar with the situation on the domestic market. It is common practice in the postharvest sector to follow advices and recommendations coming from foreign ecological and technological conditions instead applying existing domestic knowledge that is more applicable. This problem comes from the lack of cooperation between R&D institutions and wholesalers, producers and other partners in WBC cold chain. In Croatia, postharvest technology of fruits is teached at the Bs, Ms and PhD level at the University of Zagreb at Faculty of Agriculture, but it is not obligatory course, even for students of horticulture. Fortunately, students recognize the importance of postharvest sector and regulary take this course. The Agriculture faculties from Belgade, Novi Sad and Priština-Lešak have also established a study program at postharvest sector of fresh fruits and vegetables but only for master and PhD level.

Assistance with the organization of local workshops for post harvest handling would be very useful, as well as enhanced training for extension services for field assistance. These efforts, which could include publishing of technical publications on storing, sorting and packaging of fruits and vegetables, should be supported. EU standards of quality are adopted in the current legislative, but they are still not fully applied in the practice.

## Conclusion

In Croatia and Serbia there are four main problems causing high postharvest losses: the lack of adequate storage capacity, the lack of knowledge in the commercial practice (especially in the field of environmentally friendly postharvest treatments), the lack of cooperation between significant roleplayers in the cold chain (R&D institutions, wholesalers, producers and other partners) and the slow implementation of EU standards of quality. To improve situation and to decrease high losses of the horticultural products in the WBC postharvest sector there is an urgent need for establishing long-term network between all segments of this sector together to the more intensive cooperation between WBC in postharvest research.

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