Thesis book

INCREASING THE SHELF-LIFE OF TABLE TOMATO AND EARLY POTATO

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INTRODUCTION AND OBJECTIVES

Diseases arising from wrong lifestyle and diet are common, that is why demand for foods which are easily digestable, rich in vitamins and contain valuable minerals is growing. Freshly consumed table tomato and the popular early potato used both for cooking and frying can be ranked among those foodstuffs.

Growing and consumption of these horticultural produces are significant in Congo. This Middle-African country is very well suitable for this purpose because of its agro-ecological potential and production traditions. Due to the shortcomings of storage technology, however, serious quantitative and qualitative losses occur. Most of the producers fit the time of harvesting to the demand of purchase. This results in strongly limited production and high ratio of quality losses.

Knowledge and results gained during my research work of several years can be relatively well adapted and contribute to the development of storage technology of horticultural produces grown in Congo and to the determination of a reasonable shelf-life. My aim was to develop a temporary storage technology that enables the preservation of freshness and quality of table tomato and early potato from farm to fork. Thus tension in distribution, resulting from the surplus of goods occasionally appearing in Congo, could be eased and high spoilage losses could be decreased.

Advantages and disadvantages of controlled atmosphere (CA) storage of tomato are well known but often debated in Hungary. Thus research and development of controlled atmosphere storage and its use in practice are present simultaneously. Tomato, especially in the turning phase, and stored below 9-10°C is exposed to chilling injury with the exception of some varieties.

An important issue both in the research of storage technology and in the industrial practice is the role and effect of the stage of ripeness of tomato fruits after harvesting. This is why one of my aims was the detection of the effect of various storage conditions on the hybrid tomato varieties *Christina* and *Falcato* picked in two different stages of ripeness (red “table ripe” and yellowish-green “turning phase”).

Early table potato is accounted a delicacy food in the short Hungarian growing season. It is not fully ripe at optimal picking. Compared to winter potato its wound healing is faster, but because of its high water content, intensive initial speed of respiration and soft periderm early potato is more susceptible to bacterial soft rot. Shelf life of early potato can be 1-2 months only if storage conditions are optimal. Its cold storage is unfairly neglected. In the literature researchers reported about Japanese and North-American investigations. The conclusion can be drawn from these papers that quality of early potato can be preserved for longer periods than known up to now.

Timeliness of the topic of vegetable storage and marketing is underlined by the fact that in 2008 74 % of the total vegetable sales (fresh, preserved and pre-cooled, cleaned) resulted from the marketing of fresh (raw) vegetables in Europe.

The following tasks had to be fulfilled to reach my goals:

- optimization of storage conditions, especially of the gas composition to increase shelf-life and decrease quantitative and qualitative losses,
- study of the suitability of varieties, aptness of early varieties to preservation under CA conditions,
- investigate the significance of the stage of ripeness on the quality of stored produce in case of table tomato,
- study the “after-life” of produce following removal from storage in the post-harvest chain.

The backbone of my work was to investigate the stability of quality characteristics ensuring marketability, changes in color and texture of products, enzyme activity, determination of total and water soluble solids content, pH measurement, respiratory and transpiratory losses, determination of marketable proportion of produce. These examinations were completed with sensory analysis in case of early potato.

MATERIALS AND METHODS

Materials and storage conditions

Storage experiments were set in the controlled atmosphere refrigerated chambers of the Department of Refrigeration and Livestock Products' Technology, Faculty of Food Science, Corvinus University of Budapest. The research work can be divided into five periods: in the first two years two relatively well-known tomato cultivars and in the following three years early potato were investigated.

Table tomato

In the first year investigations were performed with the well-known late-autumn Dutch hybrid cultivar *Christina* originating from Nagyszénás.

Storage conditions:

Air temperature: 8-9 °C (bright red) and 11-12 °C (yellowish-green),
Relative humidity: 85-90 %, air velocity: 0,2-0,3 m/s,
Gas composition: 21 % O_2 : 0,03 % CO_2,
4 % O_2 : 2 % CO_2 (bright red),
6 % O_2 : 2 % CO_2 (yellowish-green).

Falcato long shelf-life hybrid tomato cultivar was investigated in the second year, harvested in Kecskemét area.

Storage conditions:

Air temperature: 10-11 °C (bright red) és 12-13 °C (yellowish-green),
Relative humidity: 85-90 %, air velocity: 0,2-0,3 m/s,
Gas composition: 21 % O_2 : 0,03 % CO_2,
4 % O_2 : 2 % CO_2 (bright red),
3 % O_2 : 1 % CO_2 (yellowish-green).

Storage time was 32 days for both varieties.

Early potato

In the first year cultivar *Desiree* was purchased from a wholesale dealer and stored under the following conditions for 30 days:

- 18 °C, 75-80 RH %, 21 % O_2 : 0,03 % CO_2,
- 8 °C, 80-85 RH %, 21 % O_2 : 0,03 % CO_2,
- 8 °C, 80-85 RH % and 4 % O_2+1 % CO_2,
- 8 °C, 80-85 RH % and 10 % O_2+5 % CO_2.

In the next years field-grown early cultivar *Cleopatra* harvested in the vicinity of Békéscsaba was taken into the experiments. Storage periods were 42 days, and 62 days respectively, conditions were set according to the following:

- 18 °C, 75-80 RH %, 21 % O_2 : 0,03 % CO_2,
- 8 °C, 80-85 RH %, 21 % O_2 : 0,03 % CO_2,
- 8 °C, 80-85 RH % and 12 % O_2+2 % CO_2.

Methods

Marketable proportion was assessed by a trained panel applying visual and tactile quality standards (firmness, color, health, tendency for sprouting) according to No. 1-4-778/83/95 regulation of Codex Alimentarius Hungaricus. **Respiratory and transpiratory weight losses** were always measured on the same marked tubers.

Total solids were determined by drying at 105 °C to constant weight in a Sartorius Thermo Control Infrared Dryer (typ: YTC 01 L). Changes in **total sugar** and **starch content** during storage were followed by Boehringer enzyme analytical methods. (Starch hydrolyzed into D-glucose, then phosphorylated to glucose-6-phosphate, oxidized by NADP with the formation of NADPH. Amount of NADPH was determined by means of its absorbance at 340 nm). **Peroxidase enzyme activity** was examined by modified Winter's method, with o-phenylene diamine. **ß-carotene and lycopene contents** of tomato were extracted according to Schormüller's method and measured with Beckman DU-64 spectrophotometer at 450 nm and 472 nm, respectively. The **pH value** was measured with a universal instrument type OP 211/2 using a combined glass electrode.

Colour of the surface of tomato fruits and potato tubers were tested by portable Minolta chromameter CR-200. The results were given in the CIELAB color system (L^* lightness, $+a^*$ red, -a* green, $+b^*$ yellow, -b* blue hue).

Texture parameters were measured with Instron 4302 Universal Tester with penetration method using a Holt conical needle. Beside this Texture Profile Analysis was carried out in the case of potato.

For **sensory analysis** 500 g potato was cooked in 1,5 w/v % salted water for 8 minutes. A trained panel evaluated the samples using a 5- or 9-point scale. Results were assessed by Basker's ranking method.

Statistical analysis of data was carried out by ANOVA.

RESULTS AND DISCUSSION

Marketable proportion of bright red, almost fully ripe tomato cv. *Christina* stored in CA (8-9 °C, 4 % O_2 + 2 % CO_2) was better than in normal atmosphere. Chilling injury didn't occur, weight losses were favourable and losses in solids content were moderate. Subsequent ripening and softening of fruits could be delayed only to a small degree. Because of this it is expedient to maximize shelf life in 20-22 days.

As for yellowish-green tomato stored at 11-12 °C in 6 % O_2 + 2 % CO_2 atmosphere after 15 days rapid and rather heterogeneous softening of the fruits occurred parallel with increasing coloring intensity, that was not favorable on the market in case of each treatment. In case of in CA stored tomato higher temperature (25-30 °C) and, because of the shorter treatment time, artificial ethylene addition (1 ‰ /m^3) is needed during post-ripening. Cold storage of tomato cv. *Christina* picked in yellowish-green state is not advisable for longer than 15 days even under CA conditions.

Cold CA storage of almost fully ripe tomato *Falcato* (cold forcing) can be carried out successfully. Compared to traditional cold storage advantage of CA storage (10-11 °C, 4 % O_2 + 1-2 % CO_2) is mainly in the marketable proportion. Changes in color and texture, primarily influencing consumer acceptance, were minimal during the 1-month period. Effect of ripening-inhibitor gen (rin) during storage was well detectable. No chilling injury occurred during storage, the quality of the produce was relatively good.

We had mainly negative experiences with the storage and post-ripening of tomato *Falcato* picked in yellowish-green state. Because of the retarded ripening, gradually reddening fruits were removed from storage, that were soft in great part and their consistency didn't fit to the market requirements. Tendency to coloration and development of firmness were asynchronous.

One has to stress that CA is not essential for short-term storage of tomato in Congo. Because of the lack of the technical conditions of post-storage technology it is expedient to deal with the storage of almost fully ripe tomato, but with artificial cooling.

Controlled atmosphere storage for preserving the "delicacy" character of early potato is a novelty. Our investigations proved that storability and thus marketing season of early potato cultivar *Cleopatra* could be extended by cold storage in normal or controlled atmosphere. Results showed

that in the gas composition used in our experiments (12 % O_2 + 2 % CO_2) at 8 °C aging processes could be well delayed, the produce preserved its delicacy character for more than one month.

Marketability of cold stored CA potato was better. There were no significant changes in color and firmness of tubers. Measure of changes in starch and sugar content didn't cause loss of value. For longer storage periods than reported in the present work, smell and taste of potato became less characteristic so optimal gas composition still has to be determined.

My results for both produces, but of course with other varieties, can be very well utilized in my homeland, the Republic of Congo. Research results of ambient (18 °C) storage of early potato may be used soonest in Congo. Temperature of storage and transportation has to be adjusted to the conditions in Congo.

Building of research cold stores is of high priority for the adaptation of my results to the conditions in Congo, where researchers should investigate the suitability of varieties and develop complex technologies. By building cold stores on the habitat temporary storage of surplus goods could be solved. To achieve this, farms should be joined on the model of the Hungarian Producer Organizations. Based on international experience producer organizations ensure most efficiently the continuous supply of the market, and temporary storage is one of its conditions.

Good information flow has an important role in Congo as well, thus shortcomings in marketing have to be ceased. Surveying the market, popularization of consumption of these produces through changing consumer habits stimulates demand. Establishment of agrarian marketing centers is recommended to promote marketing of agricultural products at home and abroad. I constructed a model for the development of professional marketing conditions by taking the product path in consideration.

NEW SCIENTIFIC RESULTS

1. My investigations proved that in the case of ripen, so called mid-life table tomato (cv. Christina) and the long shelf-life table tomato (cv. Falcato) application of cold and controlled atmosphere storage has demonstrable advantages in marketing in regard to preserving quality, including the marketing chain, too. The shelf-life of these varieties at 10-11 °C storage temperature in 4 % O_2 + 2 % CO_2 atmosphere is 14-21 days.

2. I determined that the mid-life table tomato picked in yellowish-greenish (25% yellow, 75% green) so called „turning" phase can be preserved in CA (11-12 °C, 6 % O_2 + 2 % CO_2) for maximum 15 days without significant quality deterioration. Artificial after-ripening before marketing is required which has to be considered at adaptation to the conditions in Congo.

Long shelf-life tomato being in the same phase of ripening is not suitable for CA storage, since its coloration and the development of fruit firmness are asynchronous which is present at after-ripening, too.

3. My investigations proved that outlook, chemical composition, organoleptic characteristics and marketability of early potato (cv. Cleopatra) can be very well preserved at 8 °C storage temperature in CA (12 % O_2 + 2 % CO_2). The produce has a very good storage potential. „Delicacy" character is preserved for at least 30 days, moreover this characteristic can be maintained under primitive marketing conditions for additional 10 days.

LIST OF PUBLICATIONS

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IF publications

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