EKOLOGIJA. 2006. Nr. 3. P. 96–104

Micromycete control in storages of succulent agricultural produce by organic technological means

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Storages of succulent agricultural produce are special biological systems. There proceed complex processes through which heat, moisture and carbon dioxide are released to the environment. They provide favorable conditions for micromycetes to develop. The employed means of microclimate control facilitate the spread of micromycetes in the environment and into the deeper layers of bulk piles. In the paper data on the efficiency of technological protection means suppressing the dispersion and development micromycetes in storages are presented.

Automatic control of ventilation systems, painting of storage walls and cleaning were found to reduce air contamination with micromycetes in a storage. Meanwhile, a suitable chemical composition of air is very important in tight storages, i.e. cold stores. In storages with active ventilation, biological activity of produce depends on ventilation mode.

On the surface of stored vegetables, the development and spreading of micromycetes was most strongly favoured by temperature fluctuations in produce piles, which provoked air condensation processes.

Key words: vegetables, potatoes, apples, storages, micromycetes, contamination, prevention

INTRODUCTION

Cleaner production technologies are being used more and more often to produce healthier organic products. Vegetable storage is one the most important moments in the production / supply chain. During storage, it is important not only to preserve the accumulated bioenergy in vegetables without worsening their quality, i.e. nutritious value and marketable appearance, but also to ensure the safety of food and raw materials.

In a storage, there develops a rather complex and active biological system whose control depends on storage mode, engineering and technological devices. During storage, all agricultural products respire absorbing oxygen and emitting water, carbon dioxide and heat (ASAE, 1985; Bakker-Arkema, 1999). Respiration intensity depends on the kind of stored produce, storage temperature, CO_2 concentration, mechanical and bacteriological contamination of products and other parameters. Active ventilation is used to eliminate respiration metabolites. The moving air spreads mycromicete propagules throughout all storage premises (Lugauskas et al., 2004).

Soil is the main source of contamination of agricultural products with micromycete propagules (Lugauskas et al., 2004).

Potatoes and vegetables are contaminated most strongly because they get in touch with the soil (Chelkowski, 1991).

Most micromycete propagules are introduced to storages together with agricultural products. The abundance of micromycetes in stored products is determined by the mycological state before loading, air humidity in the storage and many other factors. Investigations revealed (Abramson, 1991; Moss, 1991) an abundance of micromycete propagules in the air of storages, which can start developing in stored products if favorable conditions are provided.

Moisture and temperature are the most important factors for the development of micromycetes (Lugauskas et al., 2002; Lugauskas et al., 2001; Lugauskas, Stakėnienė, 2002; Смирнова, Кострова, 1989). Micromycetes do not damage wheat, barley and maize at a moisture content under 13.5% and soy seeds under 12.5% (Смирнова, Кострова, 1989). Meanwhile, even at this moisture, local development of micromycetes is possible in certain places of granaries favorable for condensate generation (Pittet, 1998). The temperature and air moisture contacting with stored product surface have the greatest effect on the development of micromycetes. It is known that any colloidal porous moist substance generates around itself a certain moisture of the environ-

ment, which is called moisture balance (ASAE, 1985; Greičius, 1999; Paulsen et al., 1983). Wheat moisture content of 13.5% and soy seed moisture content of 12.5% at 20 °C correspond to a 65–68% air moisture balance (Loewer et al., 1994). It is known that air humidity higher than 65-68% is especially favorable for micromycetes to develop (Lugauskas et al., 2002). Conditions are very favorable at the air humidity higher than 90% (Abramson et al., 2005). The air moisture balance of succulent agricultural products is above 90%. Only well dried onions have a 75% air moisture balance (Greičius, 1999; Nelson et al., 1983). The air moisture balance of potatoes ranges from 90 to 95% and of carrots, cabbage, beetroot varies between 92–98% (Novošinskas et al., 1999; Vilimas et al., 1982; Kushwaha L. et al., 1995; Leppack E., 1985).

Environmental temperature is a no less factor important for the development of micromycetes. The most favorable temperature for micromycetes is 22–35 °C (Lugauskas et al., 2002), though minimal and maximal development margins range from 5 to 45 °C (Lugauskas et al., 2004). Micromycetes of some species (*Cladosporium herbarum, Fusarium avenaceum, F. nivale,* etc.) develop below 0 °C (Abramson, 1991; Lacey et al., 1991; Beattie, 1998). During the harvest and drying of cereals, the temperature under Lithuanian conditions usually exceeds 15 °C (Vilimas et al., 1982). Storage temperatures of succulent agricultural products vary depending on stored products and storage duration. During storage, the temperature is regulated by active ventilation with air conditioning systems which employ natural or artificial heating. Cold stores usually maintain a stable temperature regime, while the chemical composition of storage air usually undergoes changes. How much it affects the mycological state of a storage is little described in the literature.

It is possible to maintain microclimate stability by both periodic and continuous ventilation systems (Raila et al., 2005). They differ in installed capacity, energy and labor input, technological equipment and environmental temperature stability. Meanwhile, no assessment of mycological systems was performed.

The aim of the present research was to establish the modes and ecological technological means to inhibit the vital and microbiological processes in succulent products and their layers.

MATERIALS AND METHODS

In 2003–2005, the mycological state of storages was investigated in five different potato, vegetables and fruit storages: a 6000 t potato storage with a continuous ventilation system, a 6000 t potato storage with a periodic ventilation system, and a 2000 t cold store for carrots and cabbage.

Potatoes for processing were stored in a 6000 t potato storage. The potato storage with a periodic ventilation system had six boxes. An automatic ventilation and air conditioning system was installed in each of them to maintain optimal storage conditions. Another storage was equipped with a microprocessor ventilation control system. The other storages had a manual ventilation control. During the cold period the temperature of the supplied air was adjusted by mixing interior and exterior air and during the warm period by artificial cold equipment. Potatoes were stored in bulk piles 5 m deep. In the storage, the ventilated air was humidified by spraying water in main air ducts. The walls and ceiling of the storage and the ventilation ducts were concrete. The storage had been operating since 1985.

In the storage with a continuous ventilation system, the intensity of ventilated air was changed automatically depending on temperature differences in the upper and bottom layers. Ventilation intensity increases at higher temperature differences. The installed air conditioning system maintains optimal storage conditions. Potatoes are stored in bulk piles 5 m deep.

Potatoes for processing were harvested by one-row GRIMME harvesters, graded by a net grading machine and stored in sections in bulk piles 4.5 m deep equipped with transporters of the same company. In the storage, potatoes were dried, healed and cooled up to the optimal temperature of 8 °C.

The cold 2000 t store was equipped with two automatic sections: one for cabbage and one for carrots. In both sections the microclimate was maintained by cooling up the interior air with the freezing equipment. The walls and ceiling were insulated with plastic covered by foam thermal insulation panels. The cooling equipment was controlled automatically. Carrots and cabbage were stored in pallet boxes. The cold store had been operating since 2003. Carrots were stored at 0–1 °C and cabbage at 0–1 °C. Carrots were harvested into smaller boxes and later emptied into pallet boxes, while cabbage was put directly into pallet boxes in the field. Pallet boxes with carrots and cabbage by electric lifts were loaded into cold stores, stacked in five layers leaving a 1.4 m wide space between the ceiling and a top pallet box and an 0.6 m wide aisle between pallet boxes and side walls. Air humidity in cold stores was not regulated. After loading with produce there formed stable 97–98% humidity. Air flow was not projected in the cold store.

The mycological state of storages was established by analyzing the amount of micromycete propagules and the micromycete species identified in the storage air and on scrapings of the storage walls.

Storage conditions were assessed by measuring the temperature and relative humidity of the storage air. Additionally the speed of air filtration was measured in the storages of potatoes for processing. The storing temperature was measured with FH A646-2 electronic thermometers and with an ALMEMO 3290 device. The microclimate inside the pile was monitored by COX TRACER sensors with an automatic data collector. Data (temperature and relative humidity of internal air) were recorded continuously every 30 minutes

throughout the whole storage period. In the storage places, visual observations were carried out as well. All changes occurring in a storage were recorded in the trial journal.

For assessment of potato quality and its changes during storage, the biochemical composition of tubers was investigated by measuring dry solids, starch, total and inverted sugars, potassium and nitrates. For determining the storage losses of succulent plant products and for other tests planned in the programme, samples were prepared at the beginning of storage. In each storage variant, samples of 20 kg were compiled from potatoes that before storing had undergone the complete treatment by the harvesting and grading machinery. Sample potatoes in net sacks were kept in the pile of stored potatoes. Each month the samples were weighed and one sack was taken away for measuring respiration intensity, micromycete prevalence and sprouting. Respiration intensity of tubers is a complex factor determining the intensity of biochemical processes during disintegration of accumulated nutrients in potatoes and activity of microorganisms. Storage losses were calculated according to changes of a sample weight.

Respiration intensity of tubers was calculated according to the comparative CO_2 emission. Based on ISO 6322/1-81 standard, we took that at aerobic respiration one mole of glucose emitted 2830 kJ.

Carbon dioxide concentration in the exiccator at certain intervals was measured by an "Infralit–2000" gas analyzer. The operation of the device is based on absorption of infrared rays. It shows CO_2 percentage in gas mixtures.

In characteristic periods, samples were taken to establish micromycete prevalence in stored produce. In addition, from each storage characteristic tuber samples were selected for analysis.

The main parameter determining storage quality for chips potatoes is a cooking test which determines the marketable appearance of products. It was performed according to the method recommended by the Estrella company.

The micromycete species prevailing in storage air were identified with an AGI-30 collector. Scrapings from storage walls at the height of produce storing collected with a sterile scraper in five different places and placed into a sterile glass container. Micromycetes were isolated and identified at the Institute of Botany.

Two agar media, Chapek – Yeast Extract Agar (CYA) and Malt Extract Agar (MEA), were used for micromycete isolation. Contaminated media were incubated in a thermostat at 26 ± 2 °C. Growing micromycete colonies were defined on the 3rd, 5th and 7th day of their cultivation. The grown micromycete were purified and identified according to cultural and morphological

Table 1. **Effect of storage treatment means on mycromicetes identified in wall scrapings**

No.	2000 t carrot and cabbage cold store		6000 t potato for processing storage		
	Without treatment		Walls painted with freshly slaked lime	Walls washed with pressurized water	
	Carrot store	Cabbage store	Premise No. 1	After washing	Before washing
1	*Penicillium chrysosporum*	*Alternaria brassicola*	*Penicillium expansum*	*Cladosporium tenuissimum*	*Acremonium fusidioides*
2	*Penicillium corymbiferum*	*Penicillium brevicompactum*	*Talaromyces flavus*	*Geomyces pannorum*	*Aspergillus repens*
3	*Penicillium expansum*	*Penicillium corymbiferum*		*Mycosphaerella brassicola*	*Mucor racemosus*
4	*Penicillium granulatum*	*Penicillium* sp.		*Oidiodendron maius*	*Penicillium compactum*
5	*Penicillium martensii*	*Rhizopus oryzae*		*Mycelia sterilia*	*Penicillium expansum*
6	*Penicillium rugulosum*	*Trichoderma viride*			*Penicillium funiculosum*
7	*Penicillium* sp.	*Mycelia sterilia*			*Penicillium roqueforti*
8	*Penicillium spinulosum*				*Penicillium viridicatum*
9	*Mycelia sterilia*				*Rhizopus oryzae*
10					*Trichoderma longibrachiatum*
11					*Trichoderma viride*
12					*Mycelia sterilia*

traits by light microscopy. Micromycete species were identified according to various descriptors (Domsch et al., 1980; Ellis, 1971; Ellis, 1976; Lugauskas et al., 2002; St. Germain, Summerbell, 1996; Zabawski, Baran, 1998).

Quantitative contamination with micromycete propagules was established by the dilution method (Trojanowska, 1991; Lugauskas et al., 2002).

The storage walls before loading were painted with freshly slaked lime or washed with pressurized water to improve their mycological state.

The results were processed by mathematical statistics methods applying Microsoft Excel XP and Statistica 5.1 programme packages. Null hypothesis between separate investigations was checked according to the F (Fisher) criterion (Степанов, 1985).

RESULTS AND DISCUSSION

Potatoes for longer storage can be harvested only fully matured. Harvesting should be finished before the average temperature falls under 5 °C.

Storages are cleaned and disinfected before harvesting. In order to make the storage process more ecologic, investigation was carried only on disinfection means that were not much environment-aggressive, i. e. wall painting with freshly slaked lime or washing with pressurized water.

The mycological state of the storages was established by analyzing scrapings from walls and air samples in storages of two different constructions: a 2000 t cold store for carrots and cabbage with the walls and ceiling covered with plastic thermal insulation panels, and a 6000 t storage of potatoes for processing with concrete walls. In the carrot and cabbage cold store the floor was cleaned, while walls were neither washed nor disinfected. In the 6000 t potato storage, after the season the walls in two premises were painted with freshly slaked lime and in the third premise with pressurized water. Scraping samples were taken before and after wall treatment.

In the 2000 t cold store, micromycetes of 9 species were found in wall scrapings of the carrot storage. Fungi from the genus *Penicillium* prevailed in scrapings (Table 1).

Micromycetes of 7 species belonging to 5 genera were identified in the cabbage storage. Besides *Penicillium* fungi, there were identified also micromycetes of the *Alternaria brasicola, Rhizopus oryzae* and *Trichoderma viride* species. In the 6000 t potato storage where the walls were painted with fresly slaked lime, no micromycetes were detected in the scrapings of the second premise, while in the first one only two micromycetes species, *Penicillium expansum* and *Talaromyces flavus*, were detected. Before painting, 12 micromycetes species belonging to 7 genera were identified in the scrapings of concrete walls. Washing of walls with pressurized water was less effective: after washing five micromycete species were identified. All of them belonged to different genera.

Painting with freshly slaked lime not only efficiently reduced the number of micromycetes on the walls, but also improved the mycological state of the storage after introduction of produce. Though after potato loading the number of micromycete species increased in the storage air in comparison to empty premises (Table 2), the number of micromycete propagules decreased from 3440 ± 1360 cfu m^{-3} in non-disinfected empty storage to 3280 ± 1460 cfu m^{-3} in the second storage premise and to 2550 ± 510 cfu m^{-3} in the first storage premise (Fig. 1).

Table 2. **Effect of freshly slaked lime on air mycological state of 6000 t potato storage**

No.	Empty and non-disinfected storage	Storage walls before loading painted with freshly slaked lime	
	Storage premise No. 6	Storage premise No. 2	Storage premise No. 1
1	*Cladosporium cladosporioides*	*Acremonium fusidioides*	*Acremonium kiliense*
2	*Cladosporium herbarum*	*Aspergillus clavatus*	*Cladosporium cladosporioides*
3	*Fusarium culmorum*	*Cladosporium cladosporioides*	*Fusarium poae*
4	*Fusarium moniliforme*	*Mortierella hyalina*	*Fusarium semitectum*
5	*Fusarium semitectum*	*Penicillium godlewskii*	*Fusarium* sp.
6	*Moniella* spp.	*Penicillium commune*	*Mortierella hyalina*
7	*Oidiodendron echinulatum*	*Penicillium corylophilum*	*Mucor hiemalis*
8	*Penicillium expansum*	*Penicillium expansum*	*Penicillium expansum*
9	*Penicillium corylophilum*	*Penicillium lanosocoeruleum*	*Penicillium verruculosum*
10	*Penicillium corymbiferum*	*Penicillium nigricans*	*Penicillium corylophilum*
11	*Penicillium melinii*	*Penicillium raciborskii*	*Penicillium janthinellum*
12	*Sclerotinia sclerotiorum*	*Penicillium stoloniferum*	*Penicillium roqueforti*
13	*Mycelia sterilia*	*Penicillium verrucosum*	*Penicillium rugulosum*
14		*Mycelia sterilia*	*Penicillium stoloniferum*
15			*Sporotrichum aurantiacus*
16			*Verticillium album*
17			*Mycelia sterilia*

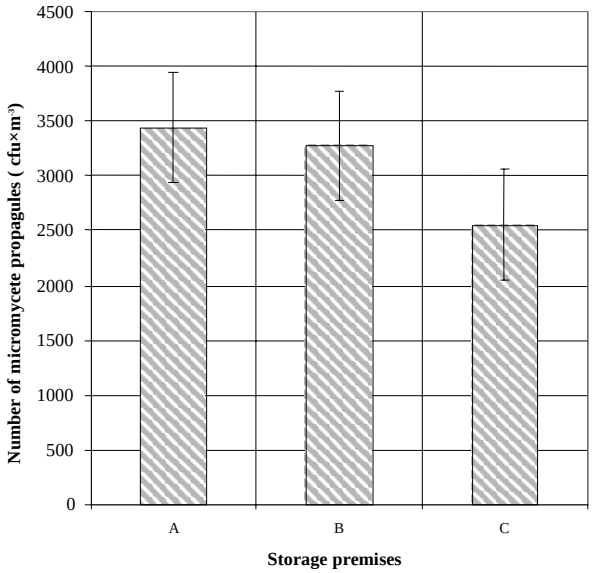

Fig. 1. Variation of micromycete propagule number in storage air depending on its preparation before loading. A – storage premises No. 6. Empty and non-disinfected storage: B – storage premises No. 2. Storage walls painted with freshly slaked lime. Potatoes newly brought from fields of the first grower; C – storage premises No 1. Storage walls painted with freshly slaked lime. Potatoes newly brought from fields of the second grower

The preparation of potato storages was the same in both premises. Freshly slaked lime was applied on the walls of not only storage but also ventilation ducts and chambers. Meanwhile, in the first premise after introduction of produce, actually 17 micromycete species belonging to 9 genera were identified in the air. In the air of the second storage, the number of detected micromycete propagules was significantly higher, though there 14 micromycetes species belonging to 6 genera were identified. This fact once more shows that the mycological state of a storage only partially depends on storage preparation. Everything starts in the field.

During harvesting and transportation, a great part of potato tubers are mechanically damaged. Tuber damages are external and internal. The degree of potato damage depends both on machinery used and tuber temperature. Another important factor is tuber maturity.

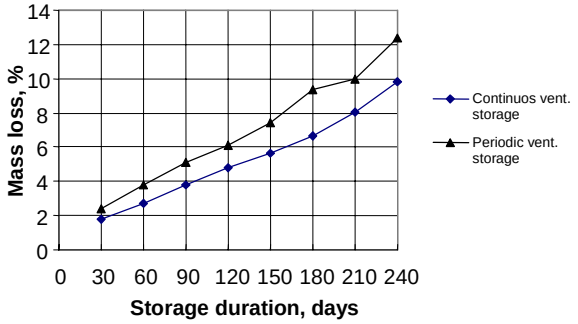

Fig. 2. Mass loss of potatoes for processing in continuous and periodic ventilation storages

When not fully matured potatoes are harvested, tuber damage rate increases during transportation, grading and loading to a storage.

The research demonstrated that in the storage of potatoes for processing very important periods are harvesting, transportation, elimination of excess moisture from the bulk pile of stored potatoes, healing of mechanic injuries, storage regime stability and continuous control of the condition of potatoes in the storage. Figure 2 shows that mass loss in potatoes for chips stored at 8 ˚C in storages with continuous and periodic ventilation systems differs little because of moisture evaporation from tubers.

The disparity forms as a consequence of different air warming when passing a potato layer at different ventilation intensity. In periodic ventilation storages, the blown air flow through the potato layer was about 100 $m^3/(t\times h)$ and in continuous ventilation storage only around 25 $m^3/(t\times h)$. Though in periodic ventilation storages more water is evaporated from stored tubers, their respiration intensity is lower and a smaller amount of micromycetes was found on tubers (Fig. 3).

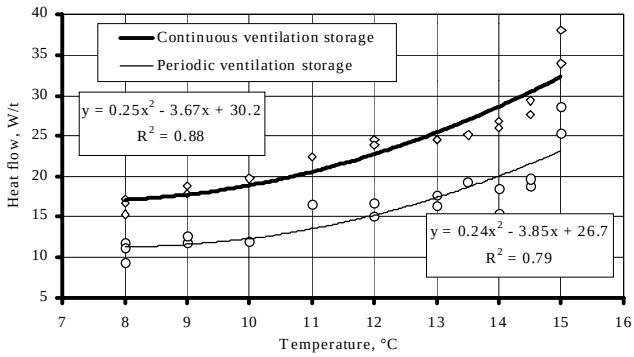

Fig. 3. Dependence of the emitted heat flow in autumn on storage temperature in 'Saturna' potatoes for processing

Stored potatoes respire by utilizing oxygen and the accumulated nutrients, and by exuding carbon dioxide, water and heat they start heating and dampening. The respiration intensity depends on potato variety, storage period and temperature, mechanic injuries. Potatoes for processing are stored at a higher temperature than seed potatoes, because they respire more intensively and consume more nutrients.

As is seen in the graph of temperature changes in the bulk of potatoes for processing (Fig. 4), in the storage where ventilation was controlled by a microprocessor the produce stored in bulk after the healing period was gradually cooled till the optimal storage temperature, and the set temperature regime during storage changed insignificantly. When the potatoes were cooled till the optimal temperature of 8 ˚C, air relative humidity in the bulk pile of potatoes changed insignificantly and was close to 95%.

The main index determining the quality of stored potatoes for chips is the color of fried chips. While processing lower quality potatoes, to improve the qual-

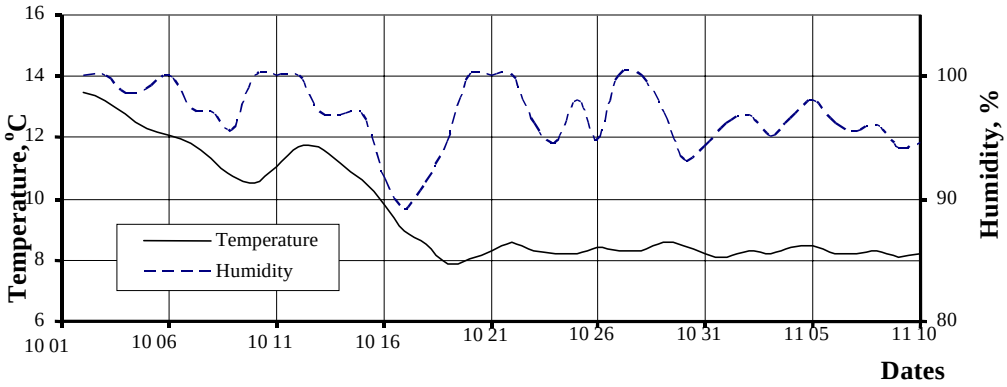

Fig. 4. Dynamics of temperature changes in a bulk pile of potatoes for processing in a box storage (ventilation control by microprocessor)

ity of chips, i.e. color, an additional operation – blanching of potato slices – requiring additional energy is introduced in the technology.

During the research frying tests of potatoes taken from various storage places were conducted. It was established that during storage the color rating of frying tests diminished from 6 to 4.5–5.5 points. Potatoes stored in the continuous ventilation storage in spring in frying tests on average were rated 5.0 points, the average quadratic error σ = 0.37. In autumn, the same potatoes taken to the storage in the frying test were rated 6.1 points. Potatoes stored in the periodic ventilation storage in spring in the frying test were rated 5.8 points, the average quadratic error σ = 0.56. In autumn, the same potatoes brought to the store on average were rated 6.3 points in the frying test.

The advantages of the periodic ventilation technology during the main storage period is that ventilation is switched on four times per 24 hours for 5–10 min each time. In this way the metabolic products of respiration are eliminated from the bulk piles, and tubers are stocked with oxygen. During the rest of the time the optimal microclimate sets in the bulk piles. In the cavities of the bulk the microclimate autoregulation process proceeds: the amount of oxygen decreases, CO_2 concentration increases, and thus inhibition of vital processes starts in stored tubers.

The peculiarity of continuous ventilation is that through a potato bulk strictly conditioned air is blown, which steadily supplies oxygen to tubers in the bulk and eliminates the metabolic products of respiration (heat, evaporated humidity, CO_2). Theoretically, in an even bulk pile it would not be difficult to implement and have a reliable potato storage technology, but in practice the technology is vulnerable, especially for storage of chips potatoes. The latter are stored at a comparatively high temperature of 8–10 ˚C. At such temperature, microbiological processes oozing respiration metabolites are intensive in potato tubers and in the bulk pile. When the bulk pile is supplied with oxygen insufficiently or metabolic products are taken away in a wrong way, sometimes the processes become difficult to control. Continuous air supply to potato bulk piles induces microbiological processes in tubers and thus worsens their quality.

The required storage temperature is usually maintained by eliminating the exuded heat from the stored produce. In the periodic ventilation storage ventilation is switched on when the temperature of exterior air is by 1–2 ºC lower than of the ventilated produce. In autumn or spring, or even in winter during thaws, it is necessary to wait until air temperature falls down and only then to switch on ventilation. The air usually cools down at night, thus it is necessary to observe and wait for the right moment. That's why manual control is tiresome, besides, not always one manages to switch on ventilation in time and make use of a brief cooling. Manual operation requires a very careful operator who knows well vegetable storage technology; otherwise good results could be hardly expected. Therefore, in modern storages the control process is automated installing various control systems. In some of them control is very precise and in others less precise. Meanwhile in the literature we found no data on the effect of control precision on the mycological state of a storage. For that reason, in the second 6000 t storage premise for processing potatoes we installed a microprocessing microclimate control system. In the first premise of the same storage an experienced operator controlled ventilation manually.

Table 3. **Comparison of storing conditions in potato storages**

	6000 t storage		4000 t storage
	Manual control	Automatic control	Manual control
Average temperature in the healing period, ˚C	15.2	14.6	13.2
Average quadratic error in the healing period, ˚C	0.9	**0.5**	1.3
Average temperature in the storage period, ˚C	11.0	9.6	11.7
Average quadratic error in the storage period, ˚C	0.8	1.3	3.3

Table 4. **Comparison of micromycete prevalence in cold store**

	CO_2 concentration in storage air, %	Identified micromycete species	Amount of micromycete propagules in 1 m^{-3} of storage air (cfu m^{-3})
Tight cold store – carrots	3–4	35	3400 ± 1150
Tight cold store – cabbage	1.6–3	33	1560 ± 390
W ell ventilated store- cabbage	0.4-0.7	14	-

For control, additionally we investigated the process of potato storage in a 4000 t potato and onion storage with ware potatoes (Table 3).

The optimal storage temperature for processing potatoes is 10 °C and for table potatoes 3–4 °C. During the healing period, in both storages the temperature should be maintained around 15 °C. The accuracy of microclimate maintenance was assessed according to average quadratic errors of recorded temperatures computed for each storage period. It was established that the automatic control system maintained storage air temperature at an accuracy of 0.5–1.3 °C in the premises.

Meanwhile during the storage period of processing potatoes in the store with manual control the temperature was by a degree higher. In the 4000 t storage premises the optimal temperature was not achieved by manual control. Therefore, no wonder that the storage air contained the highest number (12) of micromycete species. The lowest number (8) of mycromycete species was identified in the storage with automatic control. Even a higher difference was obtained by analyzing the number of micromycete propagules in the storage air. In the 4000 t storage the number of micromicete propagules reached 20500 ± 590 cfu m^{-3}, in the 6000 t storage with manual control the number being 33600±23000 cfu m^{-3}, in the storage with automatic control 13500±9000 cfu m^{-3}. The data show that a better ventilation control improves the mycological state of a storage.

Stored products respire exuding carbon dioxide, moisture and heat. During storage in modern cold stores, the temperature and humidity regime is easily balanced. Meanwhile the concentration of carbon dioxide is continually increasing up to 3–4% in the cold chamber (Table 4).

As is seen from submitted data, a significantly higher number of micromycete species was found on produce in tight stores. On carrots in a tight store prevailed *Penicillium* genus micromycetes, a great part of which may be ascribed to toxin-producing species. When carrots were stored in wooden pallet boxes and poorly ventilated, they were abundantly damaged by *Serpula lacrymans* fungi, which from wooden parts of boxes moved to carrots and incurred great losses to the farmer (Fig. 5).

Micromycetes of various *Penicillium* and *Aspergillus* species prevailed on cabbage in the cold store. The amount of micromycete species producing micotoxins

Fig. 5. *Serpula lacrymans* fungi in carrot pallet box

in the cabbage store with increased CO_2 concentration was 70% and in the ventilated store 42.9%, in the carrot store the numbers being respectively 50% and 40%.

CONCLUSIONS

1. During the whole storing period, the biological activity of potatoes stored in periodic ventilation storages was lower than of those stored in continuous ventilation stores. Periodic ventilation ensured stable potato quality and a good color of chips.

2. The technology of periodic ventilation of potato bulk piles effectively eliminates respiration metabolites from the pile, the tubers are supplied with oxygen. During the pauses, an optimal microclimate settles in the bulk pile. In cavities of the pile, the microclimate autoregulation process proceeds: oxygen content decreases, CO_2 concentration increases, and inhibition of vital processes starts in stored vegetables.

3. Temperature fluctuations, provoking humidity condensation processes in the air and dissociation of accumulated nutrients in tubers, have the greatest effect on micromycete prevalence on the surface of stored tubers in a potato bulk pile.

4. The mycological state of storage is determined by the quality of the produce.

5. An automatic control system improves the mycological state of storage.

6. CO_2 concentration in the storeroom air induces the development of undesired (harmful) micromycete species.

Received 22 May 2006
Accepted 5 August 2006

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SULTINGŲ ŽEMĖS ŪKIO PRODUKTŲ LAIKYMO TECHNOLOGIJŲ ĮTAKA SANDĖLIO EKOSISTEMAI

S a n t r a u k a

Sultingųjų žemės ūkio produktų sandėliai sudaro ypatingą biologinę sistemą. Joje vyksta sudėtingi procesai, kurių metu į aplinką išspinduliuojama šiluma, išskiriama drėgmė ir anglies dvideginis. Tai sudaro labai palankias sąlygas mikromicetams vystytis. Naudojamos mikroklimato reguliavimo priemonės padeda mikromicetams sparčiau plisti aplinkoje ir pakliūti į gilesnius produktų sampilo sluoksnius. Straipsnyje pateikiama duomenų apie gamyboje naudotinų technologinių apsaugos priemonių, stabdančių mikromicetų plitimą ir vystymąsi, poveikio efektyvumą.

Nustatyta, kad automatinis ventiliacijos sistemų valdymas, sandėlio sienų dažymas, sandėlio išvalymas mažina sandėlio oro užterštumą mikromicetais. Tačiau sandariuose sandėliuose – šaldytuvuose labai svarbi tinkama sandėlio oro cheminė sudėtis. Sandėliuose su aktyviaja ventiliacija produkcijos biologinis aktyvumas priklauso nuo produkcijos ventiliavimo būdo.

Mikromicetų vystymuisi ir paplitimui ant sandėliuojamų daržovių paviršiaus daugiausia įtakos turi temperatūros pokyčiai produktų sluoksnyje, sukeliantys ore esančios drėgmės kondensacijos procesus.

Raktažodžiai: daržovės, bulvės, obuoliai, sandėliai, mikromicetai, užterštumas, prevencija