Effective means of potatoes storage

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Abstract. For potatoes storage conditions local agricultural ores were used: Irlit 1 and Irlit 7 which differed in chemical composition. The pH reaction had differences between acidic (Irlit 7) and neutral (Irlit 1) environment. The studies were carried out in production conditions in stationary storage facilities of two republics: North Ossetia - Alania and Kabardino-Balkarian. Agricultural ore consumption per tubers ton was - 100 kg which was used depending on chemical composition and environment reaction. The experiment used the varieties Volzhanin, Udacha and Predgorny (the last of local selection). Based on the experiments carried out it was revealed that the used mixture of 2 irlites (1 and 7) had positive effect on tubers maturity, natural loss, germination of sprouts, the content of starch, vitamin C and dry matter in all studied zones of the 2 republics. The research results showed that potatoes preservation and their quality depend on the temperature regime of grown harvested products in vertical zoning conditions in RNO Alania. Potato tubers grown in the mountainous zone provided the maximum percentage of vitamin C (26-28 mg /%) depending on the varietal characteristics. Storage losses decrease also depended on the growing conditions and in the mountainous zone this figure was 2-3% lower than in piedmont and steppe zones.

1. Introduction
Potato storage is not only the final stage of agricultural production but also its the beginning. The size and quality of the future harvest, the quality of the processed products, etc., largely depends on the storage conditions of the seed material [1, 2].

All measures to satisfy necessary storage conditions for potatoes (drying tubers if they are wet, carrying out treatment period when there is mechanical and other damage, establishing the optimal temperature parameters, relative humidity of air supply and ventilation intensity) should be taken even before the first production lot arrives at the storage and observed throughout the winter up to the last tuber unloading [3, 4].

Therefore, it is possible to store potatoes successfully not using only one method no matter how effective it is but thanks to organizational and technical measures system.. There are especially large losses in potato production system during storage where they amount to 10-15% and in some cases in years when late blight epidemic occurs losses reach 25-30% or more. At the present level of potato growing development and production structure branches this is first of all tubers injury and incomplete selection during harvesting due to poor-quality preparation of harvesting equipment, insufficient capacities of mechanized storage facilities located in places of potato production, damage in city fruit and vegetable storage facilities caused by difficulties in establishing favorable storage modes for products of different quality.
As the storage period progresses tubers reaction to mechanical damage weakens and in this regard their ability to form wound peridermis and fungitoxic substances decreases. Therefore, it is very important to create such conditions after harvesting under which suberinization ability should be realized [4, 5].

The initial period of potato storage is characterized by high activity of metabolic processes and intense heat release by tubers which is associated with mechanical damage to tubers during harvesting and their adaptation to storage conditions [6, 7]. High weight losses are typical for the first month of storage due to water evaporation through damaged surfaces or through suberin skin devoid [8, 9]. The rate at which tubers lose weight during the first month of storage is often more than double that for storage period remained. Different researchers recommend different storage temperatures for treatment period [10].

After existing storage methods data analyzing it can be noted that for all varieties grown in different climatic zones it is necessary to select preservation conditions certain parameters. Thus, optimal temperature parameters recommended by different researchers differ significantly. Apparently, it is more correct to determine the optimal storage temperature for potatoes in accordance with variety characteristics. The need to take into account storage temperature effect on different varieties tubers was noted by various researchers. Thus, G.I. Matusevich [8] has got top yield of the Lorkh variety from tubers stored at temperature of 3.9-5.35 °C. Lowering the storage temperature to 1.8°C reduced the yield by 10–11%. The highest yield of Berlichingen variety was got from seed tubers stored at 1.8 °C. Storage temperature increase to 3.9 °C caused yield decrease by 10% [7-9, 11].

Consequently, the safety issues of potato tubers during storage grown in the vertical zoning of RNO-Alania have not been sufficiently studied.

The research was carried out in production conditions in three agro-climatic zones of the Republic of North Ossetia-Alania.

Our research purpose was to develop and theoretically substantiate technology elements for ecologically safe potatoes yield increasing in vertical zoning for the North Caucasus region and directly in various conditions of the republics of North Ossetia - Alania and Kabardino - Balkaria.

Research objectives:

- To study potato tubers phytosanitary state during the storage period.
- To develop methods for tubers preservation and determine their varietal differences.

Experimental schemes: 0 - control (without treatment); 1- tubers treatment with irlite 1 - 100 kg / ton of seed tubers; 2- tubers treatment with irlite 7 - 100 kg / ton of seed tubers; 3- treatment with mixture of irlites 1 and 7- 50 kg each (only 100 kg of the mixture) per 1 ton of seed tubers.

Unlike world known agro-ores natural irlites of the Republic of North Ossetia-Alania are bentonite type formations containing in optimal doses mobile forms of phosphorus, potassium, iron, manganese, nitrogen and a number of microelements valuable for plants. They also have adsorption high properties, coagulation and flocculation.

Irlit-1 is a light gray clay with a greenish tint in places with brownish-red spots of iron hydroxides and marine fauna remnants. The texture is slightly slaty. According to the mineralogical composition irlite-1 contains kaolinite, montmorillonite, glauconite, carbonate, phosphorite. Secondary dust-like are muscovite, hydromuscovite, feldspars, quartz, rutile (pH =7.3).

Irlit-7 is a clay with finer foliation. It is dominated by clay minerals kaolinite, montmorillonite, anhydrite and gypsum of which content is more than 40%. Increased phosphorus content (537 mg / kg), sulfur (2.9%), anhydrite and gypsum in irlite-7 indicates its formation due to marine flora and fauna Lower Cretaceous remains denudation and redeposition (pH = 3.8) [4].
2. Research results

Epron tubers were found to be less sensitive to increased storage temperatures. So, after storage at temperatures of 1.8 and 3.9 °C the yield was the same and only with storage temperature increase to 5.3 and 9.3 °C was yield decrease by 5 and 24% respectively.

The Epicur variety according to its storage temperature requirements terms turned out to be close to the Lorkh variety. The highest yield was obtained from tubers stored at the temperature of 5.3 °C. Lower storage temperatures for seed tubers (3.9 and 1.8 °C) reduced the yield by 4 and 16% respectively.

Studying storage conditions effect on potato tubers metabolism in the Ukraine it was found that the highest yield of Oktyabrenok and Stolichny varieties was obtained if seed tubers are stored at the temperature of 3.0-3.5 °C. Increase as well as decrease in tubers storage temperature of these varieties leads to decrease in their yield. The Katyusha variety gave a higher yield in the process of its studying when the seed tubers were stored at 2.0-2.5 °C. At the same time lowering the storage temperature to 1 °C did not reduce the yield. For Spirovic tubers variety, the optimum temperature was 5.0-5.8 °C. Storage temperature decrease in this variety led to a drop in yield [9,10].

It is known that both seed and food quality are equally determined by tuber nutrition basic elements preservation [11, 12]. If due to certain temperature conditions carbohydrates, proteins and vitamins are well preserved then this will undoubtedly have positive effect on tuber seed quality, its ability to grow, develop and give a high yield. Poor preservation of seed qualities is determined by unfavorable storage conditions that cause germination (and therefore nutrients unproductive consumption) or conversely sprouts damage by cold which is inevitably associated with changes in metabolism and the accumulation in metabolism and the accumulation of decay products. Both these lead to potatoes food quality deterioration.

During our experiments with storage temperature of 4-6 °C the losses were different for the studied varieties and variants under different conditions of potato ripening (table 1).

| Variety | № | Variant | General storage losses (%) | Sprout number | Full rot | Natural decrease | Total loss |
|---------|---|---------|----------------------------|---------------|----------|-----------------|-----------|
| Steppe zone |   |         |                            |               |          |                 |           |
| Volzhanin | 1 | control (without treatment) | 1.1 | 5.4 | 10.1 | 16.6 |
|           | 2 | Irlit -1 | 0.7 | 2.3 | 8.2 | 11.2 |
|           | 3 | Irlit -7 | 0.8 | 2.6 | 8.4 | 11.8 |
|           | 4 | Irlit -1+7 | 0.4 | 2.0 | 7.3 | 9.7 |
|           | 5 | control (without treatment) | 1.4 | 5.0 | 9.4 | 15.8 |
| Udacha | 6 | Irlit -1 | 1.0 | 2.2 | 7.3 | 10.5 |
|         | 7 | Irlit -7 | 1.0 | 2.6 | 7.6 | 11.2 |
|         | 8 | Irlit -1+7 | 0.7 | 2.0 | 6.1 | 8.8 |
|         | 9 | control (without treatment) | 1.0 | 3.8 | 9.3 | 14.1 |
| Predgorny | 10 | Irlit -1 | 0.7 | 1.8 | 8.2 | 10.7 |
|         | 11 | Irlit -7 | 0.9 | 2.0 | 8.4 | 11.3 |
|         | 12 | Irlit -1+7 | 0.4 | 1.2 | 6.9 | 8.5 |
Thus, on control variant for varieties Volzhanin, Udacha and Predgorny in the steppe zone the total losses were 16.6; 15.8 and 14.1%, piedmont 17.5; 14.8 and 14.5% and mountainous 14.8; 14.1 and 13.0%, and in the best case (joint use of irlites), losses amounted to 9.7; 8.8 and 8.5% in the steppe, 9.9; 7.6 and 7.5% in the piedmont and 8.3; 7.1 and 7.0% in the mountainous zone respectively. The maximum natural loss (respiration, damaged tubers during harvesting, processing, etc.) according to the vertical zoning results was noted for the Volzhanin variety and varied within 10.1 - 5.1%. For the Udacha and Predgorny varieties these indicators were 0.9 - 1.2% less than the control variant. Udacha is an early-ripe variety and leader buds awaken earlier than others. Accordingly, for this variety the percentage of germinated sprouts was higher in all studied ecozones.

The preservation of potato tubers was significantly influenced by natural agricultural ores. Due to the dusting of tubers with Irlit - 1 the total losses decreased by 3.3 - 4.9% in different varieties. Irlites mixture use further reduced the loss in varieties by 6.9, 7.0 and 7.5% in the steppe zone respectively and in varieties in comparison with the control variant. Varietal characteristics played positive role in

| Ecozone          | Variety | Treatment | Control (without treatment) | Irlit -1 | Irlit -7 | Irlit -1+7 | Control (without treatment) | Irlit -1 | Irlit -7 | Irlit -1+7 |
|------------------|---------|-----------|-----------------------------|---------|---------|-----------|-----------------------------|---------|---------|-----------|
| Piedmont zone    |         |           | 0.9                         | 5.8     | 10.8    | 17.5      | 0.3                         | 2.6     | 9.0     | 11.9      |
| Volzhanin        | 13      | control   | 0.8                         | 4.8     | 9.2     | 14.8      | 0.2                         | 2.2     | 7.5     | 9.9       |
|                  | 14      | Irlit -1  | 0.6                         | 2.4     | 7.6     | 10.6      | 0.1                         | 1.9     | 6.3     | 8.3       |
|                  | 15      | Irlit -7  | 1.1                         | 4.8     | 8.2     | 14.1      | 0.5                         | 2.4     | 8.4     | 11.3      |
|                  | 16      | Irlit -1+7| 0.6                         | 4.0     | 9.9     | 14.5      | 0.1                         | 1.2     | 6.2     | 7.5       |
| Udacha           |         |           | 0.9                         | 5.8     | 10.8    | 17.5      | 0.3                         | 2.6     | 9.0     | 11.9      |
|                  | 17      | control   | 1.0                         | 3.9     | 9.9     | 14.8      | 0.2                         | 2.2     | 7.5     | 9.9       |
|                  | 18      | Irlit -1  | 0.7                         | 1.6     | 7.2     | 9.5       | 0.9                         | 1.8     | 7.6     | 10.3      |
|                  | 19      | Irlit -7  | 0.9                         | 1.2     | 5.9     | 7.6       | 0.5                         | 1.2     | 5.9     | 7.6       |
|                  | 20      | Irlit -1+7| 0.5                         | 1.2     | 5.9     | 7.6       | 0.6                         | 4.0     | 9.9     | 14.5      |
| Predgorny        |         |           | 0.9                         | 5.8     | 10.8    | 17.5      | 0.3                         | 2.6     | 9.0     | 11.9      |
|                  | 21      | control   | 1.0                         | 3.9     | 9.9     | 14.8      | 0.2                         | 2.0     | 8.3     | 11.0      |
|                  | 22      | Irlit -1  | 0.7                         | 1.6     | 7.2     | 9.5       | 0.9                         | 1.8     | 7.6     | 10.3      |
|                  | 23      | Irlit -7  | 0.9                         | 1.2     | 5.9     | 7.6       | 0.5                         | 1.2     | 6.2     | 7.5       |
|                  | 24      | Irlit -1+7| 0.5                         | 1.2     | 5.9     | 7.6       | 0.6                         | 4.0     | 9.9     | 14.5      |
| Mountainous      |         |           | 0.9                         | 5.8     | 10.8    | 17.5      | 0.3                         | 2.6     | 9.0     | 11.9      |
| Volzhanin        | 25      | control   | 0.8                         | 4.8     | 9.2     | 14.8      | 0.2                         | 2.2     | 7.2     | 9.6       |
|                  | 26      | Irlit -1  | 0.6                         | 2.4     | 7.6     | 10.6      | 0.1                         | 1.9     | 6.3     | 8.3       |
|                  | 27      | Irlit -7  | 1.1                         | 4.8     | 8.2     | 14.1      | 0.5                         | 2.4     | 8.4     | 11.3      |
|                  | 28      | Irlit -1+7| 0.6                         | 2.4     | 7.6     | 10.6      | 0.1                         | 1.9     | 6.3     | 8.3       |
| Udacha           | 29      | control   | 1.1                         | 4.8     | 8.2     | 14.1      | 0.5                         | 2.4     | 8.4     | 11.3      |
|                  | 30      | Irlit -1  | 0.5                         | 2.1     | 6.9     | 9.5       | 0.8                         | 2.5     | 7.4     | 10.7      |
|                  | 31      | Irlit -7  | 1.1                         | 4.8     | 8.2     | 14.1      | 0.5                         | 2.4     | 8.4     | 11.3      |
|                  | 32      | Irlit -1+7| 0.6                         | 2.4     | 7.6     | 10.6      | 0.1                         | 1.9     | 6.3     | 8.3       |
| Predgorny        | 33      | control   | 1.1                         | 4.8     | 8.2     | 14.1      | 0.5                         | 2.4     | 8.4     | 11.3      |
|                  | 34      | Irlit -1  | 0.6                         | 2.4     | 7.6     | 10.6      | 0.1                         | 1.9     | 6.3     | 8.3       |
|                  | 35      | Irlit -7  | 0.9                         | 2.2     | 7.0     | 9.2       | 0.3                         | 2.4     | 7.5     | 10.2      |
|                  | 36      | Irlit -1+7| 0.0                         | 1.9     | 5.1     | 7.0       | 0.0                         | 1.9     | 5.1     | 7.0       |
identifying vertical zonation preservation. For example, the total losses for the Predgorny variety are 2-3% lower than for the standard Volzhin variety.

The maximum number of rotten tubers was found in the Udacha and Predgorny varieties in the mountainous zone but even there they did not exceed this indicator in relation to the standard Volzhin variety.

Therefore, the treatment of tubers before storing them with agro-ores (irlit-1, irlit-7) separately and in the mixture helps to reduce storage losses. Due to irlit-1 by 4-5%, irlit-7 by 3-4% and their combined use, losses on varieties grown in different agro-climatic zones are reduced by 5-6%.

Treating tubers influence issues before laying them for storage have not been studied enough and as our research shows tubers dusting with agro-ores contributes to the preservation of dry basis and starch due to irlites sorption capacity. Thus, in the steppe zone the decrease in dry basis and starch in the control variant was 4.3% for the Volzhin variety; 5.4% - Luck; 5.1% - piedmont to the original content. Then, as in the variant with the use of irlites 1 + 7 this indicator decreased by 2; 2; 2.5 respectively according to varieties.

There is not enough information about the various methods influence on processing tubers before laying them for storage. In this regard, it can be noted that the results of our research presented in table 2 show positive effect on the content of vitamin C and sugars during storage.

Table 2. Change in the content of sugars (%) and vitamin "C" (mg%) depending on tubers treatment from the dusty fraction of agricultural ore and the ecological cultivation zone.

| Varieties | Volzhin | Udacha | Predgorny |
|-----------|---------|--------|-----------|
|            | vitamin C | Reducing sugar | Total sugar | vitamin C | Reducing sugar | Total sugar | vitamin C | Reducing sugar | Total sugar |
| Initial content | 23.1 | 0.45 | 0.98 | 25.3 | 0.30 | 0.90 | 26.3 | 0.26 | 0.82 |
| Control | 6.23 | 0.95 | 1.85 | 7.25 | 0.74 | 1.50 | 8.25 | 0.61 | 1.30 |
| irlites -1 | 6.30 | 0.90 | 1.80 | 7.99 | 0.70 | 1.46 | 9.00 | 0.58 | 1.24 |
| irlites -7 | 6.28 | 0.92 | 1.84 | 7.21 | 0.72 | 1.48 | 9.01 | 0.60 | 1.26 |
| irlites 1+7 | 6.40 | 0.85 | 1.68 | 8.25 | 0.65 | 1.36 | 9.35 | 0.55 | 1.20 |
| Forest-steppe zone | | | | | | | | | |
| Initial content | 25.1 | 0.40 | 0.90 | 26.3 | 0.26 | 0.85 | 28.3 | 0.22 | 0.78 |
| Control | 6.35 | 0.90 | 1.80 | 8.22 | 0.70 | 1.40 | 8.99 | 0.57 | 1.24 |
| irlites -1 | 6.25 | 0.85 | 1.70 | 8.45 | 0.65 | 1.30 | 9.34 | 0.55 | 1.18 |
| irlites -7 | 6.43 | 0.87 | 1.74 | 8.41 | 0.67 | 1.36 | 9.23 | 0.56 | 1.16 |
| irlites 1+7 | 6.56 | 0.80 | 1.81 | 8.88 | 0.60 | 1.20 | 9.98 | 0.52 | 1.12 |
| Mountainous zone | | | | | | | | | |
| Initial content | 25.6 | 0.45 | 0.98 | 27.4 | 0.23 | 0.90 | 29.5 | 0.20 | 0.76 |
| Control | 6.83 | 0.85 | 1.78 | 8.87 | 0.65 | 1.40 | 9.08 | 0.55 | 1.24 |
| irlites -1 | 7.23 | 0.80 | 1.70 | 9.00 | 0.61 | 1.35 | 9.46 | 0.50 | 1.20 |
| irlites -7 | 7.12 | 0.82 | 1.72 | 8.88 | 0.63 | 1.36 | 9.32 | 0.52 | 1.22 |
| irlites 1+7 | 8.01 | 0.75 | 1.68 | 9.24 | 0.60 | 1.32 | 9.99 | 0.45 | 1.12 |
From the data given in the table it follows that tubers grown in the mountainous zone (during harvesting) contained the maximum percentage of vitamin C - 25.6; 27.4; 29.5 mg% for varieties Volzhinik, Udacha and Predgorny respectively. The indicators of the forest-steppe and steppe ecological zones were slightly inferior in this indicator to the tubers grown in the mountainous zone. During the storage period the quality indicators change greatly and as follows from our experiments results data vitamin C content decreased by 72, 67, 64 in the steppe; 74, 66, 65 - forest-steppe and 69, 66, 66% - in the mountainous zone according to the best option. For the rest of the options there was a slight decrease in comparison with the combined use of irlites 1 + 7.

3. Conclusion
It was revealed that tubers treatment before storage with agricultural ores (irlit-1 and irlit-7) separately and in a mixture helps to reduce losses during storage by 5-6%. Potatoes preservation depended on the temperature regime and the minimum losses were noted at 4-5 °C and amounted to 1.9%. Potato tubers safety also depends on the place of their cultivation that is the vertical zoning and environmental factors. It has been determined that high-altitude conditions are more favorable for potatoes cultivation and storage.

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