Tomasz FRIESKE[1], Tomasz MACIEJEWSKI[2], Katarzyna RĘBARZ[2]
[1] Agricultural Holding „Dobrynka" in Debrzno sp. z o. o. , Debrzno Wieś 41, 77-420 Lipka, Poland
[2] University of Life Sciences in Poznań, Department of Agronomy, Dojazd 11, 60-632 Poznań, Poland
e-mail: rebarz@up.poznan.pl

QUALITY CHANGES AND CROP LOSSES OF TUBERS DURING STORAGE

Summary

The experiment was conducted in a potato store in Łąkie, belonging to the farm "Dobrynka". Research factors in the experiment were: variety (Primadonna, Red Lady, Satina) and the location of containers in column (counting from the bottom - first, second, third, fourth). The potatoes were stored at 2-4^{o}C air temperature and relative humidity of 70-80%. The aim of the study was to determine quality changes and yield losses of tubers during storage. It was found that out of the studied factors, 'variety' decided most of the size and quality of the storage losses of the tubers. Regardless of the variety, the most significant natural losses were found in the mass of tubers stored on the first and second, and the smallest - on the fourth level. The studied factors had no effect on the changes in the useful value of tubers during storage.
Key words: *potatoes, storage, losses*

ZMIANY JAKOŚCIOWE ORAZ STRATY PLONU BULW W CZASIE PRZECHOWYWANIA

Streszczenie

Doświadczenie przeprowadzono w przechowalni ziemniaków w Łąkie, należącej do gospodarstwa rolnego „Dobrynka". Czynnikami badawczymi w doświadczeniu były: odmiana (Primadonna, Red Lady, Satina) oraz położenie kontenerów w kolumnie (licząc od dołu – pierwszy, drugi, trzeci, czwarty). Ziemniaki były przechowywane w temperaturze powietrza 2-4^{o}C i wilgotności względnej 70-80%. Celem badań było określenie zmian jakościowych oraz strat plonu bulw w okresie przechowywania. Stwierdzono, że z badanych czynników 'odmiana' decydowała najbardziej o wielkości strat przechowalniczych i jakości przechowywanych bulw. Niezależnie od odmiany, istotnie największe ubytki naturalne stwierdzono w masie bulw składowanych na pierwszym i drugim, a najmniejsze – na czwartym poziomie. Badane czynniki nie miały wpływu na zmiany wartości użytkowej bulw w czasie przechowywania.
Słowa kluczowe: *ziemniaki, przechowywanie, straty*

1. Introduction

The quality of the raw material in food processing is critical to the quality of the products. Among numerous factors that determine its quality, the variety has essential significance. In addition, agronomic, weather and storage conditions are also of an important meaning [11, 14, 16]. When storing potatoes, as a result of the processes of respiration and decomposition of starch as well as an increase in the content of reducing sugars, the change of the chemical composition of tubers takes place, and thus their technological usefulness may change [15]. During storage, dry matter content increases which is caused by evaporation of water. These changes may lead even to the change of the culinary type of tubers [8].

The aim of the study was to determine quality changes and yield losses of tubers during storage.

2. Methodology

The experiment was conducted in a potato store in Łąkie, belonging to the farm "Dobrynka". The potatoes originated from fields in production and were destined for food processing. The potatoes were stored at 2-4^{o}C air temperature and relative humidity of 70-80%. The potatoes after harvest, without prior sorting, were placed in storage in containers with capacity of about 1 tone of tubers. The weight of tubers in the containers was determined before they were placed in storage. The containers were arranged in vertical columns of 4 pieces each.

Research factors in the experiment were: variety (Primadonna, Red Lady, Satina) and location of containers in the column (counting from the bottom - first, second, third, fourth). The way of containers' arrangement is shown in Fig. 1.

Source: own working / Źródło: opracowanie własne
Fig. 1. Containers' arrangement *in a potato store*
Rys. 1. Ustawienie kontenerów w przechowalni

The losses in yield and the quality characteristics were assessed in two terms. The first assessment was carried out between twentieth and twenty-fifth of January, while the second between the seventh and tenth of April 2014.
On the first evaluation date in the total mass collected, the share of tubers, losses caused by diseases (wet and dry rot of tubers), mechanical damage and natural losses (loss of

water through evaporation and respiration) were specified. In the stored mass, the share of stones and soil were also determined. During the evaluation of the stored mass, the stones and soil were sorted out.

On the second term of evaluation, in sorted mass of tubers, losses resulting from the continued storage were determined.

The density of potato tubers was calculated according to the formula:

$$_b=(m_p/(m_p-m_c))\cdot \rho_c \quad [6]$$

where: ρ_b - tuber density ($g \cdot cm^{-3}$), m_p – the weight of tubers in the air (g), m_c – the weight of tubers in the liquid (g) ρ_c - density of the fluid, taking into account its temperature ($g \cdot cm^{-3}$).

3. Results

Losses arising during the storage of tubers result from a number of factors. One of the most important is the specific factor. Besides, a significant meaning have the conditions of storage of tubers as well as the technology of harvesting and weather conditions at the time.

In the own experiment, the losses caused by storage diseases resulted from varietal differences. On the first date of evaluation, the share of diseased tubers in the total weight was the smallest in the variety of Red Lady (0.17%), slightly higher in the variety of Primadonna (0.31%) and the largest in the variety of Satina (0.55%). These results indicate that Red Lady has good storage properties, even though the share of the total weight of the soil was the highest, with equally high proportion of stones. No significant effect of the vertical distribution of containers on the size of the resulting losses was found, neither any interactions between studied varieties and vertical distribution of containers (Table 1).

On the second date of assessment, the smallest losses caused by storage diseases and natural losses characterized the variety of Red Lady. Losses in the other two varieties were significantly higher and did not differ from each other. Regardless of the variety, the most significant natural losses were found in the weight of tubers stored on the first and second, and the smallest - on the fourth level (Table. 2).

Statistical evaluation that was performed showed that the changes in tuber quality characteristics during storage were small, apart from reducing sugar content, the content of which considerably increased. By the end of the storage period, dry matter content and starch as well as the density of tubers slightly increased.

4. Discussion

Changes in the content of dry matter and starch occurring in potato tubers during storage are the result of physiological processes occurring in them, such as respiration and transpiration and depend on the temperature conditions and humidity in the storage [1, 3, 10, 13].

Table 1. The share of fraction in postharvest weight on the first date of evaluation
Tab. 1. Udział frakcji w masie pozbiorowej w pierwszym terminie oceny

Factor	Level of factor	% share in the mass collected				
		tubers	losses caused by diseases	stones	soil	natural losses* [%]
Variety	Primadonna	95,3	0,31	0,13	1,62	2,64
	Red Lady	94,3	0,17	0,48	2,51	2,54
	Satina	93,0	0,55	0,60	0,59	5,26
	LSD $_{\alpha=0,05}$	1,33	0,10	r.n.	0,35	1,52
Level of container	I	93,5	0,33	0,47	1,58	4,12
	II	93,7	0,35	0,49	1,57	3,89
	III	94,3	0,34	0,35	1,57	3,44
	IV	94,4	0,31	0,36	1,53	3,40
	LSD $_{\alpha=0,05}$	r.n.	r.n.	r.n.	r.n.	r.n.

* Dry and wet rot
r.n. – differences statistically not significant

Source: own working / Źródło: opracowanie własne

Table 2. The share of fraction in postharvest weight on the second date of evaluation
Tab. 2. Udział frakcji w masie pozbiorowej w drugim terminie oceny

Factor	Level of factor	Share in the storage mass			
		healthy tubers [%]	losses caused by diseases [%]	sprouts [%]	natural losses [%]
Variety	Primadonna	97,1	0,15	0,12	2,63
	Red Lady	98,4	0,05	0,11	1,44
	Satina	97,2	0,17	0,14	2,49
	LSD $_{\alpha=0,05}$	0,68	0,09	0,03	0,62
Location of container	I	97,1	0,13	0,14	2,63
	II	97	0,19	0,15	2,66
	III	97,6	0,14	0,15	2,11
	IV	98,4	0,1	0,12	1,38
	LSD $_{\alpha=0,05}$	0,79	r.n.	r.n.	0,72

r.n. – differences statistically not significant

Source: own working / Źródło: opracowanie własne

Table 3. Changes in values in use of tubers during storage
Tab. 3. Zmiany wartości użytkowej bulw w czasie przechowywania

Variety	Term of evaluation	Parameter			
		dry matter content [%]	starch content [%]	density of tubers [g·cm^{-3}]	reducing sugars content [%]
Primadonna	initial	18,7	13,1	1,084	0,23
	I	18,9	13,2	1,087	0,67
	II	20,1	14,3	1,089	0,67
	LSD $_{\alpha=0,05}$	r.n.	r.n.	r.n.	0,15
Red Lady	initial	17,9	12,4	1,079	0,21
	I	18,4	12,7	1,081	0,67
	II	18,7	13,1	1,086	0,67
	LSD $_{\alpha=0,05}$	r.n.	r.n.	r.n.	0,18
Satina	initial	19,0	13,2	1,085	0,26
	I	19,4	13,4	1,087	0,66
	II	19,6	13,5	1,088	0,66
	LSD $_{\alpha=0,05}$	r.n.	r.n.	r.n.	0,14

r.n. – differences statistically not significant *Source: own working / Źródło: opracowanie własne*

When storing potatoes, the occurring changes were relatively minor. With the passage of storage time, dry matter and starch contents increased and following these changes – the density of tubers. A similar trend in the changes of tubers' density was also observed by Sobol [12]. The greatest changes in the content of dry matter and starch during storage were respectively 1.4% and 1.2% in the variety of Primadonna. In the case of the other varieties the changes were significantly smaller and in the variety of Red Lady they reached 0.8% and 0.7% and in the variety of Satina 0.6% and 0.3%. Also in the study by Grudzińska [5], significant differentiation in the changes of chemical composition of tubers depending on the variety was indicated.

The potatoes destined for processing must be of high quality. The suitability for processing into fried products is determined by the dry matter and starch contents. Potatoes destined for processing into chips should contain 20-22% of dry matter and 14-17% of starch, while for chips 20-25% of dry matter and 16-20% of starch [7]. The tested varieties are not intended for processing into chips and fries but are used in households for preparing them. During the store they preserved their value in use however the content of dry matter and starch was slightly lower than the requirements posed to the potatoes used for these purposes. Also the content of reducing sugars was too high to get fried products of light colour. In this study the content of them clearly increased, was stable and did not change during storage and reached 0,66-0,67% of the weight. The increase of reducing sugars during storage is a natural physiological process and in the research by Grudzińska and Zgórska [4] their content increased to more than 1%. Potatoes straight after harvest are characterised by lower content of them. However, during storage at low temperatures invertase enzyme is enabled that catalyses the breakdown of sucrose to sugars [2, 9]. This process is reversible and during the reconditioning of tubers the content of reducing sugar is significantly lower [4].

5. Conclusions

1. From the studied factors, variety decided most about the size of storage losses and the quality of stored tubers.
2. Regardless of the variety, the most significant natural losses were found in the weight of tubers stored on the first and second, and the smallest - on the fourth level.
3. The studied factors had no effect on the changes of the value in use of the tubers during storage.

6. References

[1] Burton W.G. , Van Es A., Hartmans K. J.: The physics and physiology of storage. In: The potato crop, 1992.
[2] Cottrell J.E., Duffus C.M., Paterson L., Mackay G.R., Allison M.J., Bain H.:. The effect of storage temperature on reducing sugar concentration and the activities of three amylolytic enzymes in tubers of the cultivated potato, *Solanum tuberosum* L. Potato Res., 1993, 36, 107-117.
[3] Czerko Z., Zgórska K., Grudzińska M.: Czynniki ograniczające kiełkowanie ziemniaków podczas przechowywania. Zesz. Probl. Post. Nauk Rol., 2010, 577, 243-252.
[4] Grudzińska M., Zgórska K.: Wpływ efektywności zabiegu rekondycjonowania wybranych odmian bulw ziemniaka na barwę frytek. Nauka Przyr. Technol., 2010, 4, 2, 17.
[5] Grudzińska M.: Wpływ warunków atmosferycznych i przechowalniczych na cechy technologiczne ziemniaka w produkcji frytek i chipsów. Biul. IHAR., 2012, 265, 137-148.
[6] Jakunczun H., Zgórska K., Zimnoch-Guzowska E.: An investigation of level of reducing in diploid potatoes before and after cold storage. Potato. Res., 1995, 38, 331-338.
[7] Lisińska G.: Czynniki surowcowe i technologiczne kształtujące jakość przetworów ziemniaczanych, Mat. Konf., I Konferencja Naukowa, 08–11 maja Polanica Zdrój 2000, „Ziemniak spożywczy i przemysłowy oraz jego przetwarzanie", 81-57.
[8] Mozolewski, W.: Przydatność odmian ziemniaka do przetwórstwa w zależności od czasu przechowywaniu. Cz. I. Wpływ czasu przechowywania ziemniaków na przydatność do wyrobu chipsów. Biuletyn IHAR, 2000, 213, 261-266.
[9] Nourian F., Ramaswamy H.S., Kushalappa A.C.: Kinetics of quality changes associated with potatoes stored at different temperatures. Lebensm.-Wiss. Technol., 2003, 36, 49-65.
[10] Rastovski A.: Storage losses. In: Storage of potatoes. Ed.: Rastovski A., van Es A., PUDOC, Wageningen, 1981, 169-172.
[11] Rytel E., Lisińska G., Kozicka-Pytlarz M.: Wpływ sposobu uprawy na jakość konsumpcyjną ziemniaka. Zesz. Probl. Post. Nauk Rol., 2008, 530, 259-269.
[12] Sobol Z.: Wpływ wybranych czynników na gęstość bulw ziemniaka. Acta Agrophysica, 2006, 8(1), 219-228.
[13] Sowa-Niedziałkowaska G.: Wpływ naturalnych sposobów ograniczających intensywność przemian ilościowych w bulwach ziemniaka w czasie przechowywania. Zesz. Probl. Post. Nauk Rol., 2002, 489, 355-363.
[14] Wierzbicka A.: Wybrane cechy jakości bulw ziemniaków uprawianych w systemie ekologicznym w zależności od nawadniania. – J. Res. Appl. Agric. Engng., 2011, 56(4), 203-207.
[15] Wójcik-Stopczyńska B., Baczyńska A.:. Zmiany zawartości niektórych składników bulw ziemniaka podczas przechowywania w szafie chłodniczej. Ziem. Pol., 2014, 1, 33-38.
[16] Zgórska K., Frydecka-Mazurczyk A.: Wpływ warunków w czasie wegetacji oraz temperatury przechowywania na cechy jakości ziemniaków przeznaczonych do przetwórstwa. Biul. IHAR, 2000, 213, 239-248.