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The Impact of Potato Sampling Site on Selected Texture Properties

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Summary. The paper presents the results of research on the impact of sampling site on the textural properties of potato tubers. Selected indicators of texture, i.e. hardness, fracturability, springiness, cohesiveness and chewiness were determined using double compression test TPA. The study was conducted on samples from well defined layers (upper layer, middle layer, lower layer) and zones (A, B, C), because their structure is heterogeneous. The samples were compressed in the vertical and horizontal direction. The results were statistically analyzed using Statistica 6.0. The research has shown that the sampling location has a significant impact on the value of all the parameters of potato texture. At the vertical compression of the material, the hardness decrease also caused a decline in the other studied parameters, while at the horizontal compression, in general, the increase in hardness caused the increase in fragility, cohesiveness and chewiness, while the springiness decreased.

Key words: potato, textural properties, sampling site.

INTRODUCTION

Growing consumer interest in healthy food has forced the producers to improve production conditions and selection of such varieties of potatoes that meet the requirements, depending on the destination [9, 7]. The use of potatoes is very wide, from human consumption by feed through to manufacturing. In each of these applications the potatoes are used with selected properties associated with their chemical composition [2, 5]. The chemical composition of tubers varies depending on the variety, environmental conditions and, in particular, weather conditions. In a potato tuber there is about 75% water and 25% dry mass. The energy value of potatoes is not large and is 87 kcal·100 g^{-1} (366 kJ·100 g^{-1}) [4, 17].

In recent years, we have seen changes in the use of potatoes. The use of the plants for industrial purposes, such as starch or alcohol, has been reduced (from about 3 million tonnes in 1989 to about 1 million tons in recent years). The use of potatoes in fattening animals has been steadily decreasing. Only the consumption of potatoes has remained almost constant. However, there has been an increase in processing vegetables for food [11, 12, 14].

The most important task of fruit and vegetable industry is the preservation of harvest, which allows consumption of products throughout the year. Management of fruit and vegetables on a commercial scale is a very difficult organizational sector of the food industry. Storage of potatoes requires such conditions that will reduce losses and the loss of mass of tubers and shall encourage the maintenance of selected quality characteristics required for specific directions for use. There are four stages of storing potatoes:

Stage 1 – this is the initial period of storage, which consists of drying and healing combined with cork peel. The length of this period should not last more than 2 weeks at 15°C.

Step 2 – consists in cooling the potato tubers. Within a day, the lowering of temperature in the range of 0.2-0.5°C with humidity of 90% to 95%. This period may last from 4 to 8 weeks from the start of cooling.

Step 3 – a long-term storage. At this stage the destination of the stored potatoes plays an important role . Potatoes should be stored at 5-7°C and seed at 3-5°C.

Step 4 – consists in a slow raising of the temperature to 12-15°C for 2-3 weeks in order to prepare for the use of potatoes [3, 16, 18].

Texture of the pulp is the basis to qualify for a particular type of potato utility and consumption [13]. It is a fast and objective evaluation that does not require a large amount of time and work, and allows you to get accurate results. Texture shapes our preferences and is an indicator of freshness [15]. It plays an important role in the transport and processing, as it determines the handling of the product. The application provides a comprehensive summary of product characteristics, taking into account the mechanical properties and geometry [1, 8]. The size, shape (Fig. 1), morphology and anatomy of potato (Fig. 2) have an impact on the formation of defects, both internal and external. [6]

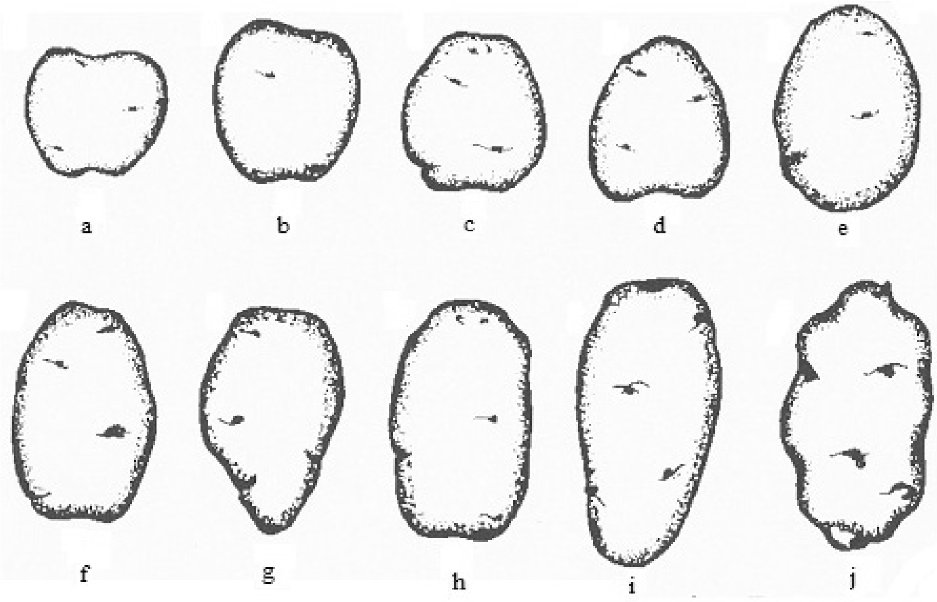

Fig. 1. Shapes of potato tubers, a – transversely oval, b – round, c, d – round-oval, e, f – oval, g, h – oblong-oval, i – elongated, j – irregular

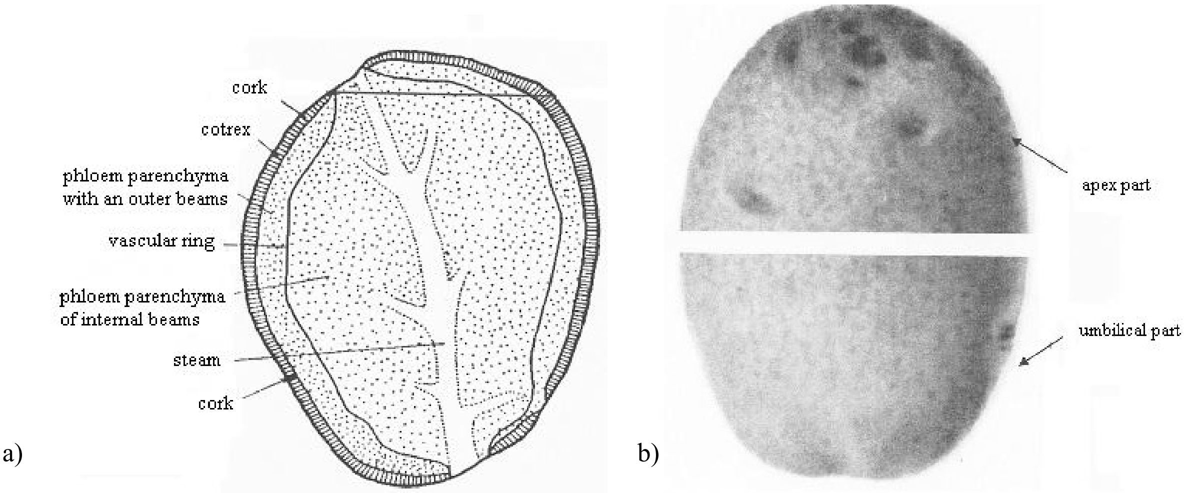

Fig. 2. Construction of a potato tuber: a) anatomical (longitudinal), b) morphological

For materials with a heterogeneous textural structure, the texture is a critical distinction for its evaluation and attributes considerable importance. Therefore, it is important to constantly test the quality of tubers [10].

OBJECTIVE AND SCOPE OF RESEARCH

The aim of this study was to investigate the effect of sampling site on the textural properties of a potato.

The scope of the study included the initial preparation of raw materials, cutting out samples of potato tubers, testing the strength of the material and their statistical description.

METHODS

The investigation included potatoes of a new variety – Madeleine. The variety is early, they have a light yellow skin and yellow flesh. The tubers are oval-oblong, they have shallow eyes and a uniform shape. They are intended for edible seed – consumer needs, suitable for French fries, chips and starch production.

The vegetables came from private field crops in the province of Lublin. The potatoes were grown on the third grade soil. Fertilization, beauty and safety measures were carried out using mechanical equipment. Harvesting was done manually in the phase of technological maturity. Acceptable vegetables were selected in terms of shape and size, items with visible signs of damage or disease were discarded. Tubers of similar, uniform shape were selected. The shape of the potatoes was similar to the round one.

Material for the study was collected from the 10th week after harvest for a period of 7 days. Vegetables were stored in a vault at the temperature not exceeding 6°C and relative humidity of 95%.

In each tuber first a slice was punched with thickness of 20 mm from the central portion toward the longitudinal direction. Then the cuboid was excised of dimensions 60x60x20 mm, which was first divided into three layers (upper, middle and lower) with the thickness of 20 mm, and then the three zones A, B and C (also the thickness of 20 mm). This resulted in cubes with 20 mm sides. The site of sample cutting is shown schematically in Fig. 3. To determine the effect of the change in mechanical properties, samples were excised from twenty potatoes. In order to be able to carry out mathematical statistical analysis, the position of the individual samples was determined. Coordinate system *x*-*y* assumed the intersection at the point 0. The *y*-axis coincides with the vertical axis of zone B, and the *x* axis with the horizontal axis of the central layer. Vertical axes in the zone A and B were spaced from the axis *y*, respectively -20 and +20 mm, and the horizontal axis of the top layer samples were also spaced about -20 and +20 mm from the axis *x*.

The tests were subjected to double compression on the texture-meter TA.XT at the speed of the head 50 mm·min^{-1}. The compression was carried out at constant 50% deformation of the sample height, and the time interval between sets was 5s. Afterwards ten samples from all were compressed in the vertical direction (*y*), and ten in the horizontal direction (*x*). Each series of tests was carried out in triplicate.

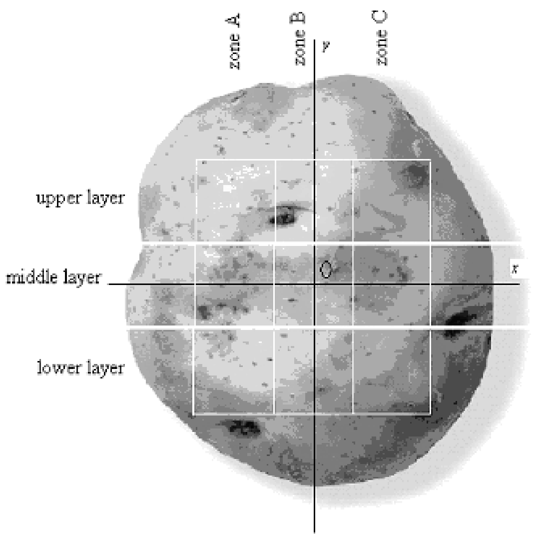

Fig. 3. Schematic of sample cutting

The analysis of the measurements in the form of texturographs of the coordinate system of two force-deformation allows a determination of the following textural parameters: hardness, fracturability, cohesiveness, springiness and chewiness:

- hardness, i.e. the maximum force during the first cycle of compression;
- fracturability, force assigned to the first significant peak in the curve of the first compression;
- springiness, that characterises the degree of recovery of the initial form;
- cohesiveness characterising the forces of internal bonds that hold the product in one piece;
- chewiness which is a measure of force required to chew a bite of food to make it ready for swallowing; it is defined as the product of hardness, cohesiveness and elasticity.

RESULTS

The average density of the raw material of the test was 1121 kg·m^{-3}, and the humidity 81.3%.

Figure 4-8 shows the values of taps in the texture of the potato depending on the place of sampling and the compression direction.

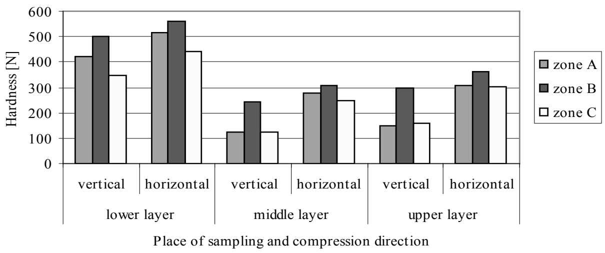

Fig. 4. The dependence of the hardness of the layer of potato and the sampling zone on the compression of raw materials vertically and horizontally

One of the parameters, which are determined by the strength tests was the hardness of potato (Fig. 4). The highest hardness of the samples was characterized by the lower layer of the tuber in the zone B when the value of the horizontal compression was 558.026 N characteristics, and with a vertical compression 502.184 N. In each case, the highest hardness of the material was found in zone B, which is the site of the core tubers.

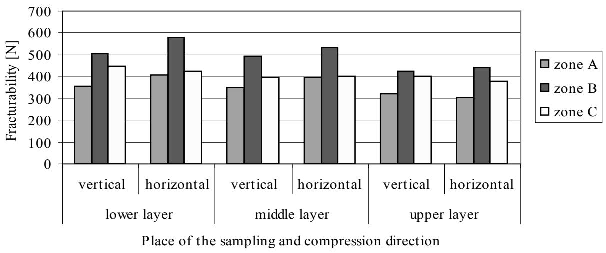

Fig. 5. Dependency of fracturability on the layer of potato and the sampling zone at the compression of raw materials vertically and horizontally

Fracturability of potato was different, depending on the location from which the test material came. The highest fracturability occured in the raw material downloaded from the bottom layer in zone B, at the horizontal compression the determinant value amounted to 582.268 N. As we got closer to the apical part, the fracturability of potato decreased: the middle layer was 530.956 and 443.488 N for the top layer. It was observed that the vertical compression fragility of the material from the core was also the largest at the top of potato and decreased as it approached the umbilical portion. The value of the determinant was in the range of 502.120 to 423.273 N.

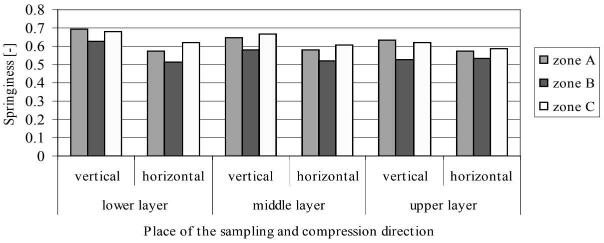

Fig. 6. Dependency of elasticity of the layer of potato and the sampling zone at the compression of raw materials vertically and horizontally

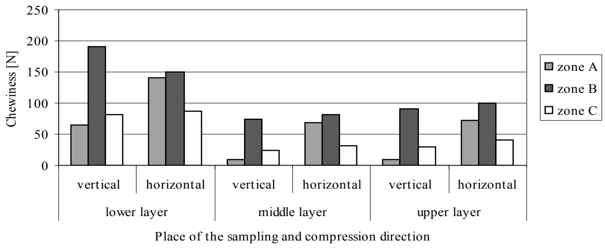

Fig. 8. Dependence of chewiness on the potato layer and sampling zone for the compression of raw materials vertically and horizontally

Another feature being determined during strength testing was springiness of the material. The potato was the least resilient in zone B, the lowest value of this feature was observed in the bottom layer with a horizontal compression, where it was 0.512. The highest springiness of the crumb samples of the tubers occurred at the lower layer of vertical compression. The values of indicators for zones A and C were respectively 0.692 and 0.683.

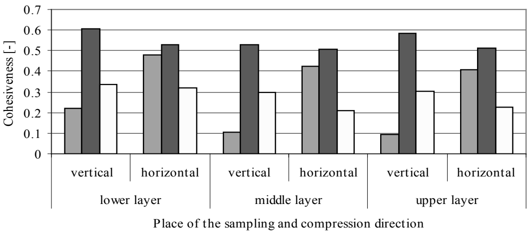

Fig. 7. Dependence of potato cohesiveness of the layer and the sampling zone at the compression of raw materials vertically and horizontally

It was observed that the cohesiveness of potato was the highest for samples from the core layers of all tubers at each direction of compression.

The highest level of chewiness was reached during the tests on the lower layer B in tubers, at vertical compression of the samples (190.645 N), and on the lowest zone in the middle layer A, the value of which was as much as 61% lower. In all cases, the smallest crumb chewiness occurred in tubers from zone A. For the bottom layer, the determinant value was 64.385 N, for the middle layer 8,539 N and for samples from the umbilical portion of the potato 8,970 N.

Based on the results it can be concluded that the material hardness decreases at vertical compression, which also causes a decline in the other studied parameters. In contrast, generally, the horizontal compression increases hardness and also causes an increase in the fracturability, cohesivenes and chewiness, while the springiness decreased.

Research on the fragility of the tubers showed that the most fragile was the material downloaded from zone B (samples compressed vertically and horizontally), that is from the core of the potato.

CONCLUSIONS

1. Sampling site has a significant effect on the value of all the parameters of potato texture.
2. During the tests, at the compression of potato vertically and horizontally it can be seen that the texture parameters of determinants, i.e. hardness, fracturability, cohesiveness, chewiness were by far the highest for the material in zone B (the position where the core of tubers is).
3. The hardness and fragility of potato was the highest in the core of tubers and in each case the determinant of texture assumed higher values at vertical compression than horizontal one.
4. For each of the layers springiness received at the lowest zone B was higher for vertical than horizontal compression.

Table 1. Regression equations and coefficients of determination R^2 describing the variability of individual determinants of potato texture shared into zones and layers as: vertical and horizontal. The equations are valid for values of *x* and *y* ranging from -20 to +20 mm and were determined at the level of statistical significance $\alpha \leq 0.05$

Determinants of texture	Compression process	Regression equations	Coefficients of determination R^2
Hardness [N]	vertical	$H = 248{,}441 - 5{,}597y - 0{,}316x^2 + 0{,}372y^2$	0,968
	horizontal	$H = 277{,}564 - 4{,}501y + 0{,}34\ y^2$	0,843
Fractubility [N]	vertical	$Fr = 480{,}030 + 2{,}205x - 1{,}805y - 0{,}259x^2$	0,897
	horizontal	$Fr = 512{,}166 - 0{,}298x^2$	0,535
Springiness [-]	vertical	$Spr = 0{,}577 - 0{,}0018y - 0{,}0002x^2$	0,949
	horizontal	$Spr = 0{,}524 + 0{,}00077x + 0{,}00017x^2$	0,912
Cohesiveness [-]	vertical	$Coh = 0{,}573 + 0{,}004x - 0{,}00087x^2$	0,938
	horizontal	$Coh = 0{,}517 - 0{,}0047x - 0{,}00043x^2$	0,888
Chewiness [N]	vertical	$Ch = 90{,}910 + 0{,}442x - 1{,}715y - 0{,}207x^2 + 0{,}104y^2$	0,898
	horizontal	$Ch = 85{,}396 - 1{,}395y - 1{,}032x + 0{,}096y^2 - 0{,}093x^2$	0,894

5. Chewiness and cohesiveness had the highest value in the core material. Higher values of cohesiveness were observed in the case of vertical compression than for horizontal one, for chewiness the values were variable.

REFERENCES

1. **Gołacki K., Rowiński P. 2006.** Dynamiczne metody pomiaru własności mechanicznych owoców i warzyw. Acta Agrophysica, 8(1), 69-82.
2. **Gozdecka G., Kaniewska J., Isbrandt M., Bandyszewska K. 2012.** Określenie zależności między wybranymi właściwościami fizykochemicznymi ziemniaków i teksturą czipsów ziemniaczanych. Zeszyty Problemowe Postępów Nauk Rolniczych, 570, 45-52.
3. **Kolowca J., Krzysztofik B., Nawara, P. 2006.** Wpływ czasu przechowywania na właściwości reologiczne bulw ziemniaka. Acta Agrophysica, 7(1), 99-104.
4. **Kolowca J., Złobecki A. 2012.** Właściwości reologiczne wysoko uwodnionych ciał stałych pochodzenia roślinnego. Acta Agrophysica, 19(4), 725-736.
5. **Marks N., Krzysztofik B., Szmigiel A. 2005.** Zależność pomiędzy zawartością związków azotowych a podatnością bulw ziemniaka na mechaniczne uszkodzenia. Inżynieria Rolnicza, 4(64), 7-14.
6. **Martens H.J., Thybo A.K. 2000.** An integrated microstructural, sensory and instrumental approach to describe potato texture. LWT-Food Science and Technology, 33(7), 471-482.
7. **Mir-Bel J., Oria R., Salvador M.L. 2009.** Influence of the vacuum break conditions on oil uptake during potato post-frying cooling. Journal of Food Engineering, 95(3), 416-422.
8. **Mitrus M., Oniszczuk T., Mościcki L. 2011.** Changes of specific mechanical energy Turing extrusion – cooking of potato starch. TEKA Commission of Motorization and Energetics in Agriculture, 11c, 200-207.
9. **Mitrus M., Wójtowicz A. 2011.** Wybrane cechy jakościowe przekąsek ekstrudowanych z dodatkiem skrobi modyfikowanych. Acta Agrophysica, 18(2), 335-345.
10. **Nadulski R., Zawiślak K., Panasiewicz M., Skwarcz J., Starek A. 2013.** Charakterystyka oporów cięcia wybranych materiałów roślinnych o zróżnicowanej budowie morfologicznej. Inżynieria i Aparatura Chemiczna, 52(3), 208-209.
11. **Oniszczuk T., Wójtowicz A., Mitrus M., Mościki L., Combrzyński M., Rejak A., Gładyszewska B. 2012.** Influence of process conditions and fillers addition on extrusion – cooking efficiency and SME of termoplastic potato starch. TEKA Commission of Motorization and Energetics in Agriculture, 12(1), 181-184.
12. **Pasławska M., Stępień B., Surma M., Jałoszyński K., Drożdż W. 2011.** Charakterystyka suszenia wycierki ziemniaczanej w złożu fontannowym. Inżynieria Rolnicza, 5(130), 215-221.
13. **Rojo F.J., Vincent J.F.V. 2009.** Objective and subjective measurement of the crispness of crisps from four potato varieties. Engineering Failure Analysis, 16, 2698–2704.
14. **Sykut B., Kowalik K., Opielak M. 2005.** Badanie wpływu kątów ostrza i przystawienia na opory krojenia produktów spożywczych. Inżynieria Rolnicza, 9(69), 339-344.
15. **Ślaska-Grzywna B. 2006.** Wpływ obróbki termicznej na siłę cięcia i siłę ściskania ziemniaków. Inżynieria Rolnicza, 6(81), 333-339.
16. **Tajner-Czopek A. 2003.** The changes of pectin substances concentration in potatoes and french fries and the effect of those substances on the texture of the final product. Nahrung/Food, 47(4), 228-231.
17. **Tajner-Czopek A., Kita A., Pęksa A., Lisinska G. 2003.** Quality of French fries as dependent on potato variety and the content of polysaccharides in tubers. Horticulture and Vegetable Growing, 22(4), 158-166.
18. **Thybo A.K., Martens M. 1999.** Instrumental and sensory characterization of cooked potato texture. Journal of Texture Studies, 30(3), 259-278.

WPŁYW MIEJSCA POBRANIA PRÓBEK NA WYBRANE WYZNACZNIKI TEKSTURY ZIEMNIAKA

Streszczenie. W pracy przedstawiono wyniki badań wpływu miejsca pobrania próbki na właściwości teksturalne bulwy ziemniaka. Wybrane wskaźniki tekstury, tj. twardość, kruchość, sprężystość, kohezyjność oraz żujność określono za pomocą testu podwójnego ściskania TPA. Badania przeprowadzono na próbkach pobranych ze ściśle określonych warstw (warstwa górna, warstwa środkowa, dolna) i stref (A, B, C), ponieważ jego struktura jest niejednorodna. Próbki były ściskane w kierunku pionowym i poziomym. Uzyskane wyniki opracowano statystycznie korzystając z programu Statistica 6.0. Z badań wynika, że miejsce pobrania próby ma istotny wpływ na wartość wszystkich parametrów tekstury ziemniaka. Dla materiału ściskanego pionowo spadek twardości powoduje również spadek pozostałych badanych parametrów, natomiast dla surowca ściskanego poziomo wzrost twardości powoduje wzrost kruchości, kohezyjności oraz żujności i spadek sprężystości.
Słowa kluczowe: ziemniak, właściwości teksturalne, miejsce pobrania próbki.