



## CARBOHYDRATES IN VARIETIES OF STORED POTATOES AND INFLUENCE OF STORAGE ON QUALITY OF FRIED PRODUCTS

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### ABSTRACT

The research presented in this work deals with the issue of changes in carbohydrate representation of potato tubers at 11 varieties due to their storage. Time of storage effect on starch and reducing sugars content was examined. The lowest reducing sugar content was observed at the end of the storage at the variety of Markies (0.15%). Sensory quality of the fried potato chips and French fries was assessed by the international system (Colour cards for quality evaluation of potato chips). Best varieties, that showed (even after 6 months of storage) the highest sensory assessment at French fries (9), were Agria and Vladan. In case of potato chips the highest rating was 7 points (Laura, Mark, Vladan) after the storage time.

**Keywords:** chips, reducing sugars, dry matter, starch, potatoes

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## INTRODUCTION

The main compound of potato dry matter is starch. Also important are other polysaccharides in terms of health benefits - fiber, hemicellulose, pectins, and others. The most significant carbohydrates are sucrose, glucose and fructose (**Bárta et al., 2008**).

The starch content ranges from 10 to 25% in fresh matter of tubers. It consists of amylose and amylopectin, in ratio 2:8. To obtain starch as raw material for the starch industry and industrial production of ethanol are suitable varieties with higher starch content of more than 20% (**Czerko et al., 2008**).

Starch in potato tubers is considered to be the most important energy substance, it accounts for approximately 68% of the total dry matter of tubers (**Šmálik, 1987**). The quality of tubers is closely related to properties of potato starch by its heat treatment in which the changes occur in the structure of cells and bulbs in terms of physico - chemical properties of starch. Thermal effect on starch causes its swelling and cracking of the cells. This process can cause stickiness and softening at cooking processing of potatoes (**Šmálik, 1987; Frydecka-Mazurczyk et al., 2000**).

Simple sugars are in tubers represented as sucrose, glucose and fructose. Average content of simple sugars is 0.5 to 2.0% of the total weight of the tuber. Under wrong conditions of storage (low temperature), the content can be increased up to 5% or more. In October the glucose content of potatoes is typically from 0.5 to 2.0%, fructose from 0.02 to 0.10% and sucrose from 0.25 to 0.60% (**Mareček et al., 2009**).

The level of sugars in potato tubers is affected by variety, maturity of the tubers at harvest, the influence of year and very important is storage temperature. Effect of storage temperature is important in particular at affecting the levels of reducing sugars, glucose and fructose, which at their higher contents significantly contribute to the deterioration of fried potato products.

After storage of tubers at low temperature (2-3°C), the increase of reducing sugar content is found, and high level is observed until the end of the storage period. Tubers stored at a higher temperature (8-10°C) do not accumulate sugars. Reducing sugar level is kept in terms of impact on the quality of fried products at an acceptable level. The modest increase occurs at the end of the storage period due to aging of tubers (**Mareček et al, 2008**).

The content of reducing sugars in tubers at low storage temperature can be reduced by storage of the tubers at higher temperatures shortly before processing. It was confirmed the correlation between the content of reducing sugars and the quality of fried chips (**Popr, 1996**).

The maximum acceptable amount of the reducing sugar content for the production of fried chips and French fries is reported between 0.18 to 0.25%. During processing technology, or culinary preparation of potatoes, their color changes occur, which may be desirable, because they are characteristic for products. But in general, these color changes may adversely affect the quality. Besides other properties, such as dry matter content and starch content, tendency to change color is very important for the selection of tubers for a particular processing.

During the processing, color changes are induced by formation of intensely colored products. After cutting, enzyme reactions are becoming and last color changes are called “blackening” after cooking.

Enzymatic browning is caused by enzyme oxidation of phenols, which occurs after contact of the enzyme polyphenoloxidases with substrate (phenol and oxygen) after discontinuation of native cellular structures. The intensity of color changes is affected by the content of tyrosine and o-diphenols (chlorogenic acid, catechins, and others) and the activity of enzymes in the tubers (**Mareček et al., 2008**).

To minimize the production of dark-colored chips, processors need varieties with low reducing sugars, mainly fructose and glucose. Non-enzymatic browning is important in the production of chips, French fries, to a certain extent also in the dried mashed potato and other similar products. Color changes are mainly affected by the content of reducing sugars, for frying at high temperatures is important sucrose content and browning intensity can be decreased by ascorbic acid (**Coop et al., 2000**).

The aim of the work was the quantification of important components for the production of food products (potato chips, French fries) - starch and reducing sugar contents and their variability due to storage of selected varieties. The sensory quality of fried potato products was evaluated by international standards for color scale.

## **MATERIAL AND METHODS**

### **Material**

A set of 11 varieties, cultivated in Slovakia by major producers of potatoes, was evaluated.

**Agria:** medium early to medium late variety, cooking type B-B/C,

**Colette:** cooking type B, early variety,

**Marabel:** cooking type B, medium-early variety,

**Laura:** cooking type B, medium-early variety,  
**Markies:** medium-late variety and late variety, cooking type B/C,  
**Ramos:** early variety, cooking type C/B,  
**Red Anna:** medium early variety, cooking type B-B/A,  
**Santé:** medium early to medium late variety, cooking type B,  
**Victoria:** cooking type B-B/C, medium-early variety,  
**Viola:** early variety, cooking type B,  
**Vladan:** variety suitable for processing, rich in starch.

Varieties of potatoes harvested in 2011 were evaluated. Tuber varieties were analyzed after harvesting, at the beginning of September. Selected chemical parameters (dry matter, starch content, reducing sugars) were determined. The varieties were treated by frying in vegetable oil and processed as potato products - chips and French fries. After frying, sensory evaluation of product color was done.

Storage took place for 6 months in a cool room at 5°C and under relative humidity 87%. Tubers were controlled during their storage for disease and spoilage monitoring. Sprouting treatment was not carried out. The same analyses of tubers and their processed products (chips and French fries) were done after tuber storage.

### **Parameters of chemical analysis**

- Starch content (%) - by Ewers polarimetric method,
- Reducing sugar content (%) - by the method of Luff-Schoorl,
- Dry matter content (%) - pre-drying of the sample at 65°C (3 hours) and drying at 105°C (3 hours) to constant weight (ISO 712).

Sensory evaluation of fried chips was performed by the Colour cards for quality evaluation of potato chips, issued by The Institute of Storage and Processing of Agricultural Produce, Wageningen, The Netherlands.

The rating system is accepted by the European Association for Potato Research (scale color of fried products range from 9 to 1 point). Evaluation method is also used in the Slovak Republic at varieties registration (the Central and Testing Institute in agriculture in Bratislava, Slovakia (ÚKSÚP)). Evaluation was done by five trained evaluators.

After the treatment cut slices of tubers of thickness 0.5 to 1.0 mm were fried at 160 ° C in sunflower vegetable oil for 2-3 minutes to the intensity of color. French fries of 5 mm width and length 30-50 mm were fried at 170 ° C for 4-5 minutes to the intensity of color.

## RESULTS AND DISCUSSION

Representation of processed products from potatoes at the market is low and is only up to 3% of edible potatoes production. The reason for this is the lack of high-quality raw materials, lack of adequate storage facilities with controlled atmosphere and market problems. For the production of fried products specific varieties of potatoes are cultivated, or suitable varieties with specific properties are tested. The basic requirements include demands for tuber shape, size, chemical composition, resistance to sprouting. Suitable tubers are round, measuring from 40 to 70 mm, with shallow eyes, in a good health state.

Dry matter content of potatoes is suitable more than 20% and the content of starch should be not less than 14 - 17%. The specific requirements include reducing sugars, glucose and fructose content. The optimum content is up to 0.2%. To keep a low reducing sugar content is very difficult. Under the influences of storage, starch is gradually decomposed into simpler components and the content of reducing sugars proportionally increases. The main factor that affects reducing sugar content is the temperature in the storage area. If the temperature falls during more than 10 days to below 2 ° C, the decomposition of starch is accelerating. For this reason the potatoes for food processing are recommended to store at the temperatures at 7 to 10 °C, to avoid the decomposition of starch.

The ideal food product is yellow, with no signs of turning to brown or spots. Reducing sugars at frying at high temperatures react with other ingredients, and the result are dark stains and darkening of product. This area of food processing and research is little understood. The main ingredient of tubers is water. Higher water contents are typical for early potatoes. In recent years lower dry matter contents of potatoes are recorded. The reason is mainly the cultivation of varieties of foreign origin which have been bred in different conditions. The another reason is better offer for earlier versus late varieties. For the storage are medium late varieties and late varieties are suitable. They tend to have low germination and are more stable in the composition (Korenko, *et al.*, 2009).

The dry matter content measured in the tubers ranged from 20.59% to 25.15%. The highest dry matter content was found to be after harvest, at varieties Ramos (24.85%), and Vladan (25.15%). Dry matter content is proportional to the starch content of tubers. After

harvesting, starch content is the highest and due to storage gradually decreases (Sowokinos, 2001).

The highest starch content was measured at variety Vladan (20.43%). For other varieties starch content was determined in the range of 14.12% to 17.65%. Normal starch content after harvest in potato tubers ranges from 14-17%. According to the measured results, all observed varieties have optimum starch content. The starch content of tubers is affected by variety, location, climatic conditions and fertilization. In the dry matter, the starch is represented by 60% - 70%. The largest content was detected in the variety Vladan (81.23%). This variety can be described as highly starchy.

Reducing sugars were determined within the range of 0.07 to 0.26% before the storage. The lowest reducing sugar content in fresh matter was found at varieties of Markies and Ramos (0.05%) and Agria (0.07%). More than 0.20%, showed varieties Victoria (0.23%) and Viola (0.26%). In the dry matter, the proportion of reducing sugars is 0.20% - 1.26%. As it can be seen from the results in Table 1, the expression per dry matter showed other quantitative statement.

**Table 1** Dry mater (DM), starch and reducing sugars content at the begining of storage (%)

Variety	DM	Starch	Starch in DM	Reducing sugars	Reducing sugars in DM
Agria	22.15	16.87	76.16	0.07	0.32
Colette	21.32	15.46	72.51	0.15	0.70
Marabel	23.51	16.74	71.20	0.09	0.38
Laura	20.85	15.13	72.57	0.16	0.76
Markies	23.66	16.92	71.51	0.05	0.21
Ramos	24.85	17.65	71.03	0.05	0.20
Red Anna	21.25	15.16	71.34	0.19	0.89
Santé	22.08	16.38	74.18	0.14	0.63
Victoria	21.30	14.74	69.20	0.23	1.08
Viola	20.59	14.12	68.58	0.26	1.26
Vladan	25.15	20.43	81.23	0.11	0.44

After analysis at the beginning of storage, tubers were stored under standard conditions for 6 months. The aim was to assess the effect of time of storage on tuber components for longer-term storage under the same conditions. During storage, significant effects were not observed, e.g. the occurrence of diseases or wilt.

After a period of 6 months of storage (table 2), at 9 varieties in dry matter content was found a slight increase, due to loss of water in the tubers, but also due to the loss by breathing. Results were in the range of 20.36% to 24.76%. Varieties Viola (-0.23%), and Vladan

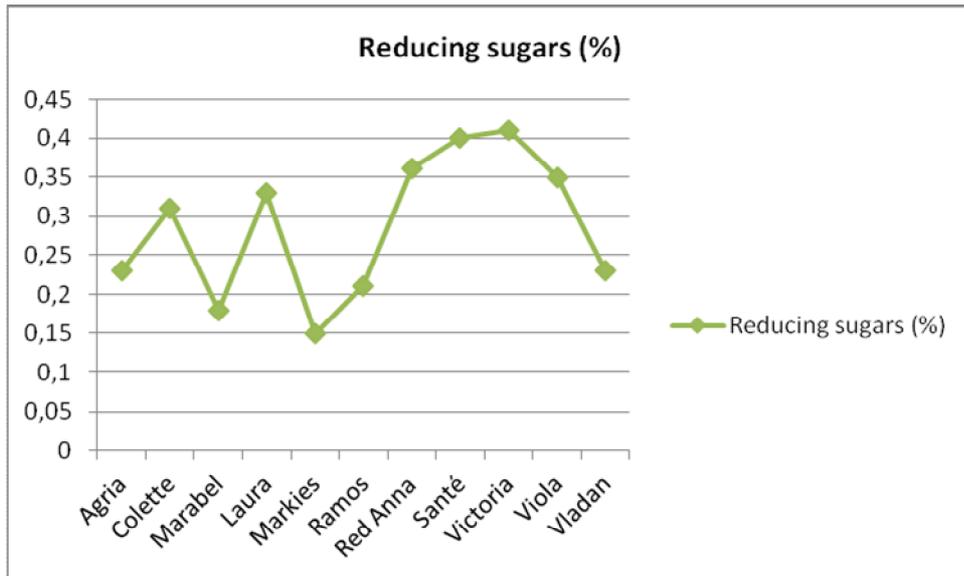
(-0.39%) were determined with a slight decrease of dry matter content compared to the values in the first sampling.

Major differences were recorded among varieties (11.62 - 17.52%) in the starch content. For all tested varieties, the decrease in starch content was measured. More than 14% of the starch content was found at Vladan (17.52%), Ramos (15.86%), Mark (14.89%) and Agria (14.25%). The proportion of starch in dry matter decreased to 57.56% - 70.76%. The content of reducing sugars in the evaluated varieties increased. Less than 0.20% showed Markies variety (0.15%) and Marabel (0.18%). The highest content was found to be in Santé (0.40%) and Victoria (0.41%). In the dry matter, the representation of reducing sugars was in the range from 0.63% (Mark) to 1.88% (Victoria).

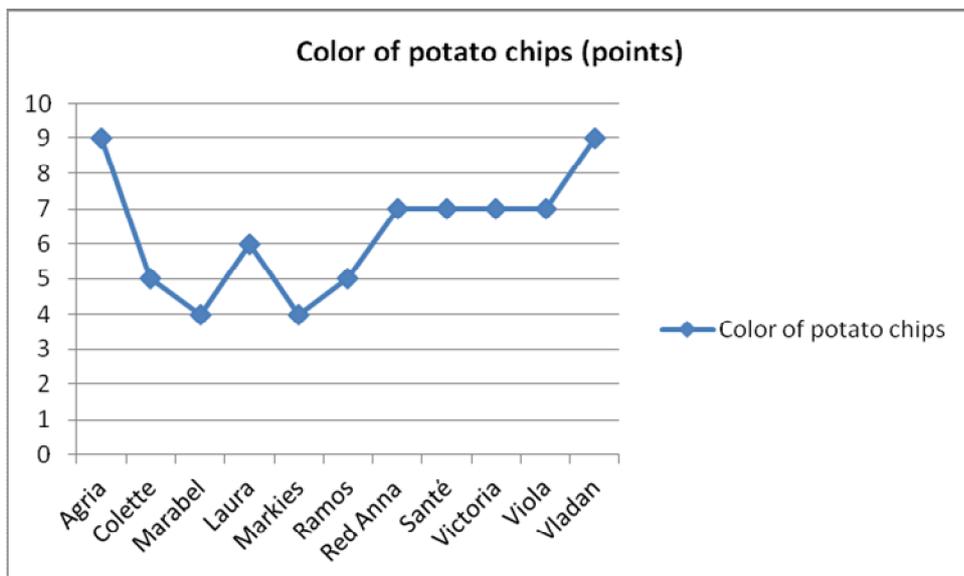
**Table 2** Dry mater (DM), starch and reducing sugars content at the end of storage (%)

Variety	DM	Starch	Starch in DM	Reducing sugars	Reducing sugars in DM
Agria	22.53	14.25	63.25	0.23	1.02
Colette	21.62	12.63	58.42	0.31	1.42
Marabel	23.63	14.13	59.80	0.18	0.76
Laura	21.26	11.63	54.70	0.33	1.55
Markies	23.85	14.89	62.43	0.15	0.63
Ramos	25.10	15.86	63.19	0.21	0.84
Red Anna	21.63	13.21	61.07	0.36	1.66
Santé	22.16	13.25	59.79	0.40	1.80
Victoria	21.82	12.56	57.56	0.41	1.88
Viola	20.36	11.89	58.40	0.35	1.72
Vladan	24.76	17.52	70.76	0.23	0.93

After cleaning and peeling, tubers were sliced and fried. Treatment with anti-browning blanching was not carried out. Frying was performed according to the methodology in vegetable oil (sunflower oil, acid value of 0.24 mg KOH.g<sup>-1</sup>). After heat treatment, sensory evaluation with the original 9-point international scale IBVL was performed, which is internationally accepted and used.



**Figure 1** Reducing sugar content after 6 months of storage (%)



**Figure 2** Color of potatoe chips after 6 months of storage (points)

The highest rating for chips and French fries is 9 points. The product has intensive yellow color with no browning and staining. The highest ranking at the beginning of storage obtained at potato chips varieties Agria, Santé and Vladan (9) and at the French fries Vladan (9). The lowest values were 6 points (Marabel, Ramos). After storage the highest rating obtained varieties Agria and Vladan (9). At French fries, 9 or 8 points received none variety (table 3). Storage was significantly affecting the quality of the resulting sensory quality of French fries (Wang *et al.*, 1999).

**Table 3** Evaluation of chips and French fries (points)

Variety	Potatoe chips (1. sampling)	Potatoe chips (2. sampling)	French fries (1.sampling)	French fries (2.sampling)
Agria	9	9	7	6
Colette	7	5	7	6
Marabel	6	4	7	5
Laura	7	6	8	7
Markies	8	7	8	7
Ramos	6	5	8	6
Red Anna	8	7	8	5
Santé	9	7	8	5
Victoria	8	7	7	6
Viola	7	7	7	5
Vladan	9	9	9	7

1. sampling –beginning of storage, 2. sampling – end of storage

## CONCLUSION

Results of this research work showed specific signs of edible potato varieties under their storage. These changes were reflected in the chemical composition and sensory quality of fried potato chips and French fries. In terms of the storage stability and low levels of reducing sugars to storage are suitable varieties Marabel, Markies and Ramos. The most suitable varieties for food processing, especially for potato chips are varieties Agria and Vladan due to maintainance of appropriate parameters (reducing sugars) during storage. In terms of chemical composition, the low content of glucose and fructose is not completely proportional to the resulting high quality product fried.

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