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REGULAR ARTICLE

CHANGES OF CARBOHYDRATES COMPLEX INFLUENCED BY THE STORAGE TIME

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ABSTRACT

The basic chemical composition of potatoes is significantly influenced by variety. The dry matter content in evaluated varieties ranged from 20.68% (variety Vivaldi) to 25.12% (variety Jupiter). Even after three months of storage, the dry matter content was above 20% for all varieties. The largest decrease in dry matter was measured in variety Tomensa (0.60%). Correlation between starch content and the vegetation period was confirmed, when the lowest starch content was measured in a very early and early varieties. Levels of simple and reducing sugars during storage increased slightly in all varieties. Adora variety showed the lowest content of reducing sugars by both collections (up 0.20%), which meets the requirements for the production of chips (max. 0.25% reducing sugars). The highest values of reducing sugars showed varieties Victoria and Desire. Based on an overall assessment of carbohydrates as well as their changes during storage, varieties can be recommended for the production of food products and starch.

Keywords: consume potatoes, variety, carbohydrates, storage, food products

INTRODUCTION

Potatoes are still one of the dominant components of human nutrition among population in Slovakia, even though their consumption from year to year declines. Potatoes are consumed either directly or in the form of food products such as peeled potatoes, cooked, frozen, dried and fried products. Quality of potato is by several authors referred as file of parameters or a set of criteria that are demanded from tubers for a particular use of consumers **(Prugar *et al.*, 2008)**. To produce high-quality and market attractive tubers there is a wide selection of varieties available for the potato processors and for individual groups of customers that are involved in processing potatoes. At present, there are over 1300 registered varieties in the common catalogue in Slovakia. Variety is one of the key factors that contribute to the resulting quality of tubers **(Velíšek *et al.*, 2002)**. Potato quality, consistency and other characteristics are affected by starch content in tubers, which is determined by soil and climatic conditions in different growing years. In years with lower average temperatures and optimal distributed precipitation, consume potatoes have a higher table value, are less mealy, with a stable softer consistency **(Mareček, 2003)**. **Hamouz *et al.* (1997)** found a higher average content of starch in the tuber, which is a measure of tubers maturity, in potatoes grown in sugar beet farming locality compared to the same varieties grown in potato farming locality. The starch content is a varietal characteristic **(Lamberti *et al.*, 2004)** and proportion of variety at the total starch variability is 65%, the share of environmental conditions is 19% and the share of variety and environment interaction is 14%. Generally, with increasing vegetation time the starch content increases as well. The quality of potato products depends mainly on the chemical composition of tubers **(Burlingame *et al.*, 2009)**. Depending on the type of potatoes products very important is dry matter content, which should be in the potatoes for French fries from 20 to 22%, for chips from 21 to 24%, for dried products from 21 to 25% and for sterilized potatoes from 18 to 20%. The dry matter content also determines the texture of chips, French fries and dried rehydrated products **(Domkářová and Vokál, 2002)**.

Carbohydrate content in potatoes depends on a variety and on physiological state of tubers, while the presence of carbohydrates may change during tuber development and during the time of storage **(Vreugdenhil *et al.*, 2007)**. **Bojňanská *et al.* (2008)** states that at storing temperatures from 10 to 20 ° C, is in mature tubers the most of the carbohydrates in the form of starch. Other sugars are present in small amounts **(Knowels *et al.* 2009, Zhanga *et al.*, 2002)**. A major issue is the change in colour of the products during processing, which is due

to a high content of reducing sugars and free amino acids. In fried chips and French fries due to the high content of reducing sugars, reactions with amino acids and thus formation of brown products could occur. The colour and flavour of products deteriorates **(Hrabě and Komár, 2003, Rop *et al.* 2009)**.

In terms of food security great attention should by paid to the content of acrylamide (AA) in foods and in particular to the possibilities to minimize its contents in the food processing. **Prugar *et al.* (2008)** states that acrylamide in raw potato tubers is not present but arises only in the thermal treatments from the precursors contained in the tubers, such as reducing sugars and the amino acid asparagine. The formation of AA required high temperatures around 150 °C achieved by frying or baking and potentially dangerous are only products of thermal treatment (fried chips and fries). The higher content of AA is except processing technologies influenced by the factors that influence the content of precursors. This is especially the variety and the temperature during storage of potatoes. Varieties suitable for the processing of fried products are therefore varieties with low content of reducing sugars and the storage temperature of potatoes should be in the range 8-10 °C.

The aim of this work was to assess the quality of consume potatoes in terms of representation of carbohydrates in the dry matter and then to monitor and evaluate the changes of carbohydrates after three months of potatoes storage. Based on experimental results it could by recommend to use monitored varieties for the food products production.

MATERIALS AND METHODS

Eleven varieties of consume potatoes from the harvest year 2009 were evaluated. Potatoes were grown in sugar beet growing and production area and after a period of post-harvest ripening which lasted four weeks (healing of cuts, expiring and gradual hardening), potatoes were stored in potatoes warehouse. They were stored in boxes separately for each variety at 8 °C and relative humidity of 85%. Samples were analyzed immediately before storage and after three months of storage in an amount of 25 tubers of each variety.

The following varieties were analyzed:

- Adora, Vivaldi (very early),
- Monaliza, Tomensa, Lady Claire, Baltica (early),
- Lipta, Jupiter, Victoria (medium early),

- Desire, Panda (medium late).

Evaluated technological quality parameters:

- The dry matter content (%) - gravimetric method, drying samples to constant weight
- Starch content (%) - Ewers polarimetric method according to Ewers
- The content of simple carbohydrates (%) – colorimetric method
- The content of reducing sugars (%) - by the method of Schoorl

RESULTS AND DISCUSSION

Chemical composition of potatoes has a great influence on all directions of potatoes processing, starting with storage and ending with finished products (tab. 2). As the **Prugar *et al.* (2008)** state, dry matter content could range from 16 to 32% of fresh material and is strongly dependent on variety, farming techniques, soil characteristics and course of climatic conditions. During the time of storage, the chemical composition of different varieties changed apparently. Starch content and dry matter in tubers decreased in all varieties (tab. 2). On the other hand, the value of simple and reducing sugars in tubers increased in all varieties (tab. 2). The dry matter content at the beginning ranged from 20.68% (variety Vivaldi) to 25.12% (variety Jupiter), (tab. 2). Even after three months of storage, the dry matter content was above 20% in all varieties. According to **Domkářová and Vokál (2002)**, dry matter content also determines the texture of chips, French fries and rehydrated dried products. Carbohydrate content in potatoes depends on a variety and on the physiological state of tubers, while the presence of carbohydrates may change during the crop development and storage conditions **(Vreugdenhil *et al.*, 2007)**. Levels of reducing and simple carbohydrates during storage increased slightly in all varieties (tab. 2). Variety Adora showed the lowest content of reducing sugars in both collections (up 0.20%), which meets the requirements for the production of chips (max. 0.25% reducing sugars). The highest values of reducing sugars were measured in varieties Victoria and Desire. **Bojňanská *et al.* (2008)** state that at storing temperatures from 10 to 20 ° C, is in mature tubers the most of the carbohydrates in the form of starch. Other sugars are present in small amounts **(Knowels *et al.* 2009, Zhanga *et al.*, 2002)**. By monitoring the carbohydrate complex changes after three months it was found out that the declared varieties suitable for production of chips respectively French fries as Lipta, Baltica, Lady Claire did not reach the required parameters. Variety Lipta and Lady Claire

exceeded the content of reducing sugars (0.26%) and also variety Baltica (0.30%), (tab. 2). For lower starch content we classified the mentioned varieties suitable for potatoes products use such as peeled potatoes, potato salad, mashed potatoes etc.

Varieties that reported the required amount of reducing sugars below 0.25% and hence suitability for fried products (chips) were Panda (0.20%), Tomense (0.20%) and Jupiter (0.22%), (tab. 3). Higher starch content in varieties Panda (17.9%), Jupiter (20.1%), Tomense (21.6%) and especially higher dry matter in varieties Panda (23.0%), Tomense (24.3%), Jupiter (24.8%) make them suitable for processing into dried food products even for the industrial production of starch (tab. 1). The high dry matter content is a presumption for high starch content **(Lamberti *et al.*, 2004)**. The high dry matter content provides a good yield of product, affecting its quality and processing profitability.

Variety Adora showed appropriate parameters of reducing sugars for use of variety for production of chips, by both collections (0.18%) and (0.20%), (tab. 2). This assessment made this variety also suitable for the production of fried products (French fries, croquettes, etc.). The highest values of reducing sugars achieved varieties Victoria and Desire (0.46%), Vivaldi (0.38%) and Monaliza (0.36%), (tab. 2). For the production of French fries the most suitable starch content (14-15%) was measured only in varieties Monaliza (14.5%) and Victoria (14.6%), (tab. 2). Variety Vivaldi exceeded this limit of starch (16.32%) and failed for production of French fries (tab. 4). Variety Desire (23.2%) is not suitable for production of chips (20-23%) due to high value of dry matter (tab. 1). If dry matter content is low, chips and French fries would be too soft **(Murniecea *et al.*, 2011)**. Too high content of dry matter causes that the fries would be too hard and dry, chips would be soft and crumbly. On the other hand, low dry matter content during the processing of potatoes for French fries and chips could cause need for more energy to vaporize the water. At higher dry matter, less evaporation is needed, which reduces the costs for products processing **(Rop *et al.*, 2009)**.

In terms of quality of food products, the dry matter content affects product texture (chips and fries crunchiness) especially. In addition it affects the fat content of fried products, while with its increase the fat content decrease which is better for consumer's health. The dry matter content of potatoes for direct consumption is crucial whether the consumer prefers mealy potato varieties (higher dry matter content), or tallowish potato (lower dry matter content).

Table 1 Suitability of evaluated varieties for production of dried potato products

Parameter	Reducing sugars (%)	Starch (%)	Dry matter (%)	Remark
Standard	**Optimum 0.2**	**15 – 19 Early potatoes 14**	**21 – 25**	
Desiré	0.46	15.1	23.20	-
Vivaldi	0.38	16.32	20.10	-
Baltica	0.30	16.30	21.23	-
Lady Claire	0.26	18.20	24.0	-
Jupiter	0.22	20.1	24.80	Starch production
Tomensa	0.20	21.60	24.3	Starch production
Panda	0.20	17.90	23.0	Starch production

Table 2 Changes in carbohydrate complex during storage of varieties

Variety/collection	Dry matter (%)	Starch (%)	Reducing sugars (%)	Simple sugars (%)
Jupiter I.	25.12	20.62	0.18	0.40
Jupiter II.	24.80	20.10	0.22	0.45
diference	**-0.32**	**-0.52**	**+0.04**	**+0.05**
Tomensa I.	24.90	21.89	0.15	0.39
Tomensa II.	24.30	21.60	0.20	0.39
diference	**-0.60**	**-0.29**	**+0.05**	**+0.00**
Lady Claire I.	24.10	18.42	0.21	0.45
Lady Blaire II.	24.00	18.20	0.26	0.48
diference	**-0.10**	**-0.22**	**+0.05**	**+0.03**
Desiré I.	23.78	15.26	0.42	0.49
Desiré II.	23.20	15.10	0.46	0.50
diference	**-0.58**	**-0.16**	**+0.04**	**+0.01**
Panda I.	23.07	17.92	0.20	0.44
Panda II.	23.00	17.90	0.20	0.46
diference	**-0.07**	**-0.02**	**+0.00**	**+0.02**
Monaliza I.	22.44	14.55	0.33	0.58
Monaliza II.	22.15	14.50	0.36	0.60
diference	**-0.29**	**-0.05**	**+0.03**	**+0.02**
Victoria I.	22.17	14.62	0.46	0.68
Victoria II.	21.90	14.60	0.46	0.69
diference	**-0.27**	**-0.02**	**+0.00**	**+0.01**
Lipta I.	21.30	16.17	0.22	0.38

Lipta II.	21.10	16.10	0.26	0.42
diference	**-0.20**	**-0.07**	**+0.04**	**+0.04**
Baltica I.	21.28	15.62	0.21	0.39
Baltica II.	21.23	15.30	0.30	0.51
diference	**-0.05**	**-0.32**	**+0.09**	**+0.12**
Adora I.	21.13	15.80	0.18	0.26
Adora II.	21.00	15.00	0.20	0.28
diference	**-0.13**	**-0.80**	**+0.02**	**+0.02**
Vivaldi I.	20.68	16.69	0.35	0.61
Vivaldi II.	20.10	16.32	0.38	0.70
diference	**-0.58**	**-0.37**	**+0.20**	**+0.09**

Table 3 Suitability of evaluated varieties for production of fried potato products (chips)

Parameter	**Reducing sugars (%)**	**Starch (%)**	**Dry matter (%)**	**Remark**
Standard	**Optimum 0.2**	**15 – 19 Early potatoes 14**	**21 – 25**	
Adora	0.2	15.0	21.0	-
Panda	0.2	17.9	23.0	-
Tomensa	0.2	21.6	24.3	-
Jupiter	0.22	20.1	24.8	-

Table 4 Suitability of evaluated varieties for production of wet potato products

Parameter	**Reducing sugars (%)**	**Starch (%)**	**Dry matter (%)**	**Remark**
Standard	**Optimum 0,2**	**15 – 19 Early potatoes 14**	**21 – 25**	
Lipta	0.26	16.1	21.1	-
Vivaldi	0.38	16.3	20.1	Dried products
Baltica	0.30	15.3	21.2	Dried products

CONCLUSION

Variety Adora showed appropriate parameters of reducing sugars for use of variety for production of chips, by both collections (0.18%) and (0.20%) during monitored storage period. This assessment made this variety also suitable for the production of fried products

(French fries, croquettes, etc.). For the production of French fries only two varieties Monaliza and Victoria were suitable, due to the starch content. Varieties Lipta, Lady Claire, Baltica exceeded the content of reducing sugars and due to higher starch content in variety Lipta are those varieties suitable for food use for wet products such as peeled potatoes, potato salad, mashed potatoes etc.

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