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CHANGES IN REDUCING SUGARS AND SUCROSE DURING STORAGE OF POTATO TUBERS FROM NEW CLONES

ALTERAÇÃO DOS NÍVEIS DE AÇÚÇARES REDUTORES E SACAROSE DURANTE O ARMAZENAMENTO DOS TUBÉRCULOS DE BATATA DE NOVOS CLONES

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SUMMARY

Tubers from three unnamed clones and the cultivar Red Pontiac were stored at 1° or 8°C or maintained at 20°C. The tubers in cold storage were held for 30, 60 or 90 days, then reconditioned at 20°C for 10 days. Some were maintained at 1° or 8°C for 180 days. No major differences were detected among all clones under the temperature regimes and storage periods studied. Storage at 1°C stimulated reducing sugar and sucrose accumulation, particularly in the first weeks. No accumulation was detected for tubers stored at 8°C or 20°C. Reconditioning lowered somewhat the reducing sugar and sucrose concentrations.

Key words: storage, **Solanum tuberosum** L., biochemical alteration of potato tuber.

RESUMO

Tubérculos de três novos clones de batata e da cv. "Red Pontiac" foram armazenados sob temperaturas de 1°C, 8°C e 20°C. Os tubérculos armazenados sob condições de baixas temperaturas foram mantidos por 30, 60, 90 ou 180 dias e posteriormente recondicionados por 10 dias a 20°C. Nenhuma diferença significativa foi detectada entre os clones sob as condições estudadas. O armazenamento a 1°C estimulou o acúmulo de açúcares redutores e sacarose, principalmente nas primeiras semanas. O recondicionamento a 20°C reduziu estas concentrações.

Palavras-chave: armazenamento, **Solanum tuberosum** L., alterações bioquímicas de tubérculos.

INTRODUCTION

Most potatoes used in the processing industry have been stored at low temperatures. Their suitability depends not only upon their quality at harvest but also upon their response to storage conditions.

Sugars and starch are the primary components affected by post-harvest metabolism in potato tubers. It is known that storage of potato tubers at 0-6°C causes sucrose and reducing sugars to accumulate (POLLACK & REES, 1974; COFFIN et al, 1987).

Sucrose, fructose and glucose are the major tuber sugars with others being present in trace amounts. Sugars are responsible for the production of dark colors during frying (MARQUEZ & ANON, 1986) but not all sugars contribute equally (SOWOKINOS et al, 1987). Most research indicates that only the reducing sugar content is related to the final degree of darkening in the finished product (HABIB & BROWN, 1957; TALBURT & SMITH, 1959; HOOVER & XANDER, 1961; SCHWIMMER et al, 1957; WEAVER et al, 1972). Although sucrose is generally the most abundant soluble sugar in potatoes, it is not a reducing sugar, does not participate directly in the Maillard reaction, and therefore does not contribute directly to chip color (SHALLENBERGER et al, 1959). The rate of sugar accumulation depends largely on variety (BROWN & MACKAY, 1989) and storage temperature (DENNY & THORNTON, 1941; SCHWIMMER et al, 1954). Color is one of the most important factor in defining the quality of the potato chips (LOISELLE et al, 1990).

The low temperature used to maintain tubers for extended periods of time causes an increase in the sugar content of most cultivars. Tubers high in reducing sugars produce French fries and chips which are dark in color. This is due to nonenzymatic browning reactions involving reducing sugars and amine groups of free amino acids (HABIB & BROWN, 1957) during the

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the frying process.

The main purpose of this study was to examine how the potato clones with protein content somewhat higher than normal perform during different storage temperatures with respect to the content of reducing sugars and sucrose.

MATERIAL AND METHODS

Three unnamed clones 74-48-24, 77-3-3 and 77-4-9 and the variety "Red Pontiac" were included in this experiment. Each of the unnamed clones have the "Superior" cultivar in their pedigrees, and "Denali" is the female parent of the latter two.

After harvest all tubers were stored in burlap bags and kept in constant temperature rooms in the dark with air circulation and a relative humidity of 85 to 95%. Tubers were held at 20°C for 10 days, then transferred either to 1°C or 8°C or maintained at the initial temperature of 20°C. The tubers in cold storage (1°C and 8°C) were held for 30, 60 or 90 days, then reconditioned at 20°C for 10 days. Some were maintained at 1°C and 8°C for 6 months (180 days). At harvest, samples of each variety were analyzed for reducing sugars and sucrose. Analysis was repeated after 10, 40, 70, 100, 110 and 180 days. The analysis of reducing sugars and sucrose of each treatment was replicated 5 times, using a completely randomized design.

To obtain a test piece, a 10mm diameter cork borer was punched through the center of each tuber. The cores were then cut to a uniform length of 2.0cm and cut in half from apical to basal and weighed. One of the pieces was analyzed for reducing sugars and the other for sucrose plus reducing sugars. Reducing sugars were analyzed by the method described by LINDSAY (1973). For determining sucrose plus reducing sugars the sample was incubated at 37°C for one hour with 1ml of invertase, then analyzed by the above method. The value of sucrose was determined by difference between reducing sugars.

RESULTS

No major differences were detected among all clones under the temperature regimes and storage periods studied, and no interaction between clones and temperatures was observed. Thus, the results will be presented as an average of the four clones.

- Reducing Sugars in Tubers Stored at Different Temperatures

Average reducing sugar levels during storage and reconditioning for all clones, are shown in Figure 1,

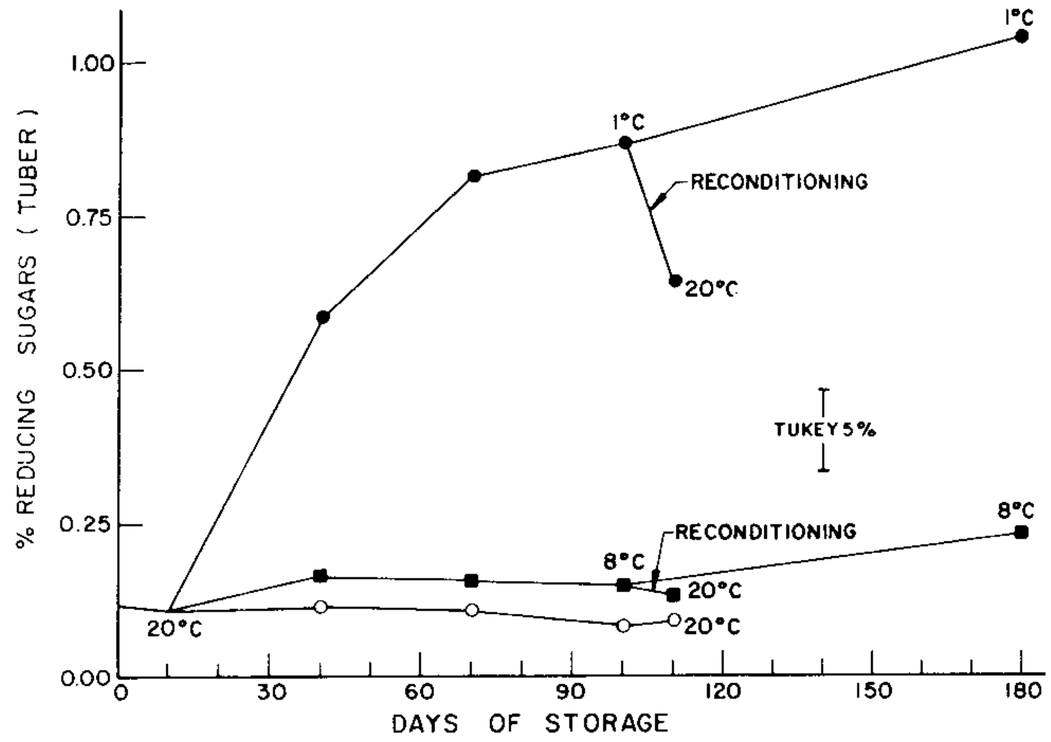

FIGURE 1 - Reducing sugar levels during storage at three temperature regimes. Average for four clones (% fresh weight).

each point represents 20 samples.

Storage at 1°C stimulated reducing sugars accumulation, particularly in the first weeks. After 30 days of storage at this temperature a 5-fold increase was observed in the concentration of reducing sugars, thereafter their accumulation occurred at slower rate. Reconditioning the tubers at 20°C after ninety days of cold storage lowered the reducing sugar concentration to levels very similar to that of 30 days-stored tubers (Table 1).

Reducing sugars accumulation in tubers stored at 8°C and 20°C was almost nil having a non-significant increase only after 170 days of storage at 8°C (Figure 1).

- Sucrose During Storage at Different Temperatures

The general pattern of sucrose accumulation is

TABLE 1 - Reducing sugar concentrations during storage of tubers at 1°C.

Days Stored	% Reducing Sugars of Clones (Wet Basis)			
	74-48-24	77-3-3	77-4-9	Red Pontiac
Harvest	0.13 c	0.12 c	0.12 c	0.10 d
10 days at 20°C	0.13 c	0.10 c	0.10 c	0.12 d
30 days at 1°C	0.63 b	0.53 b	0.51 b	0.64 bc
60 days at 1°C	0.68 b	0.85a	0.90a	0.86ab
90 days at 1°C	0.72 b	0.86a	0.97a	0.93a
*Reconditioning	0.63 b	0.70ab	0.63 b	0.58 c
170 days at 1°C	1.10a	0.89a	1.11a	1.07a

Unlike letters within columns are significantly different at 5% level by the Tukey's test.
*Reconditioning at 20°C for 10 days, after 90 days at 1°C.

shown in Figure 2. Storage at 1°C stimulated its accumulation, mainly during the first weeks. From the beginning of the cold storage period at this temperature up to 30 days after, the sucrose concentration increased more than seven times and then leveled off. Reconditioning at 20°C for 10 days reduced its concentrations to values lower than the concentration at 30 days of storage but still higher than the values found at the beginning of the storage period (Table 2).

Although there seems to be a slight difference in accumulation of sucrose between 8°C and 20°C this difference was not significant (Figure 2).

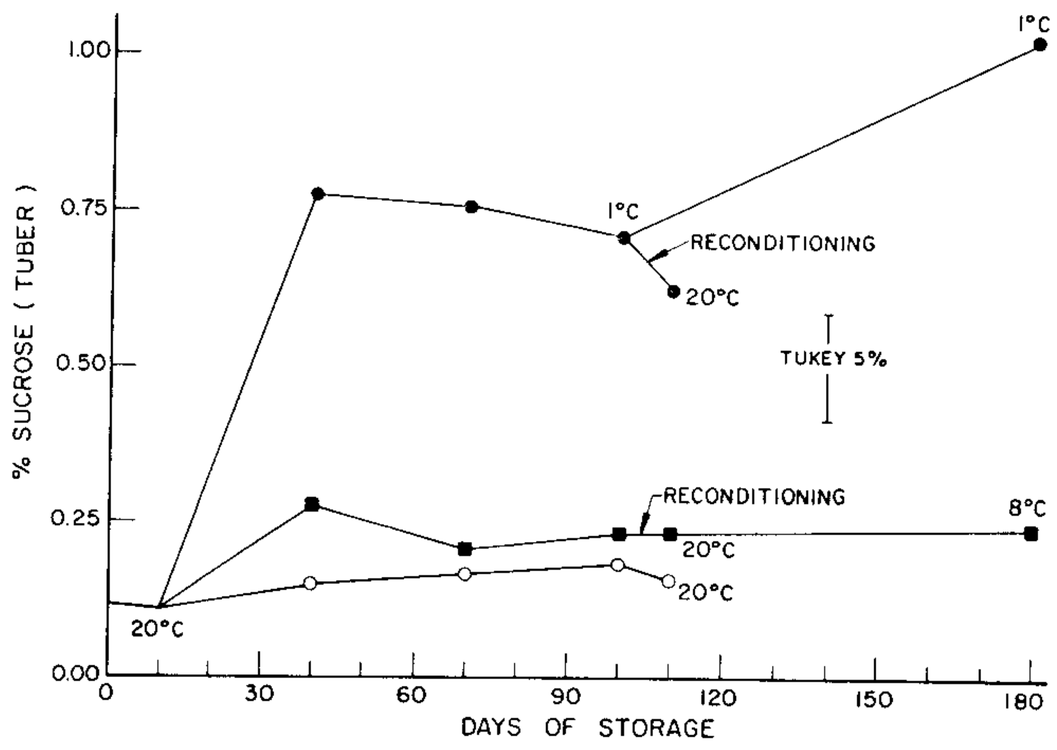

FIGURE 2 - Sucrose levels during storage at three temperatures regimes. Average for four clones (% fresh weight).

TABLE 2 - Sucrose concentration during storage of tubers at 1°C.

Days Stored	% Reducing Sugars of Clones (Wet Basis)			
	74-48-24	77-3-3	77-4-9	Red Pontiac
Harvest	0.17 b	0.09 d	0.11 b	0.11 c
10 days at 20°C	0.11 b	0.08 d	0.12 b	0.11 c
30 days at 1°C	0.70a	0.86 b	0.75a	0.79ab
60 days at 1°C	0.84a	0.69 bc	0.70a	0.82ab
90 days at 1°C	0.79a	0.72 bc	0.66a	0.76ab
*Reconditioning	0.66a	0.56 c	0.60a	0.67 b
170 days at 1°C	0.93a	1.23a	0.83a	1.13a

Unlike letters within columns are significantly different at 5% level by the Tukey's test.
*Reconditioning at 20°C for 10 days, after 90 days at 1°C.

DISCUSSION

Storage temperatures as low as 8°C may not appreciably change the reducing sugar level during storage over a period of six months. Considerable change does occur at 1°C. Upon being transferred from 20°C to 1°C the sucrose accumulation exceeded that of reducing sugars after 30 days. From 40 to 180 days tubers held at 1°C continued to show a slight accumulation of reducing sugars.

All clones accumulated some reducing sugar at 8°C, but not in sufficient amounts to cause browning in French fries. This was also reported by DENNY & THORNTON (1941). Red Pontiac at 8°C accumulated a little more than the other three clones. Clone 74-48-24 accumulated more reducing sugar than clones 77-3-3 and 77-4-9 upon being transferred from 20°C to 1°C, but leveled off after 40 days. Clones 77-3-3 and 77-4-9 continued to accumulate from 40 to 100 days, reaching levels of 0.83 and 1.0% respectively.

Ten days of reconditioning (20°C) after 90 days of storage at 1°C was insufficient to reach initial value of reducing sugars in all clones. The percentage reducing sugars lost through reconditioning was higher for 77-4-9 and Red Pontiac in comparison to clones 74-48-24 and 77-3-3, possibly because their levels were higher.

Very little sucrose was accumulated during storage at 8°C and 20°C. clone 74-48-24 and Red Pontiac accumulated some sucrose from 40 to 180 days at 8°C. None accumulated sucrose at 20°C. All clones accumulated considerable sucrose upon being transferred from 20°C to 1°C. However, sucrose decreased after 40 days at 1°C for 77-3-3 and 77-4-9 while 74-48-24 and Red Pontiac continued to accumulate sucrose until 70 days when a reduction occurred. After 180 days in storage at 1°C clone 77-3-3 accumulated significantly more sucrose than the other two numbered clones. Reconditioning at 20°C for 10 days following 90 days following 90 days storage at 1°C was insufficient to reduce sucrose to the initial level for any of the four clones.

Clones 74-48-24 and 77-4-9 had more reducing sugars than sucrose at 1°C after 180 days, whereas clones 77-3-3 and Red Pontiac showed the opposite.

Differrences between clones is apparent in their tendency to accumulate sucrose and reducing sugar under given storage conditions. The length of post-harvest conditioning has an influence on sugar accumulation during subsequent cold storage, which was also shown by BURTON (1969).

CONCLUSIONS

While the higher storage temperatures are desirable because sugar accumulation does not take

place, temperatures of 8°C and 20°C are impractical for prolonged storage because of relatively high losses in total tuber weight. This is the result of evaporation and respiration, and increased sprouting and decay. Lower temperatures (1°C) prevent sprouting. None of these clones had sprouted after 180 days at 1°C storage, and tubers were in good condition. The clones showed the same behavior during storage at 1°C.

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