

Changes in Sugar Content of Potato Stored at Low Temperature During Reconditioning

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Reconditioning에 의한 저온저장 감자의 당변화

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Abstract

To measure the optimum reconditioning period, potatoes stored at low temperatures (0°C, 5°C and 10°C) for three months were reconditioned at 20°C. Contents of glucose, fructose and sucrose of halved and whole potatoes were monitored during the course of storage and reconditioning. In halved potatoes basal portion contained higher amount of glucose, fructose and sucrose. The sugars in basal portion decreased more rapidly than those in apical portion, and sucrose disappeared fastest among the sugars in both portions during reconditioning period. The relationship between reducing sugar and reconditioning period could be presented as exponential equation. In consideration of uneven distribution of sugar contents between apical and basal portion, the required optimum reconditioning period at 20°C could be 1.3 weeks, 5.6 weeks and 9.4 weeks for potatoes stored at 10°C, 5°C and 0°C, respectively.

Introduction

Storage temperature influences many physiological processes in potatoes. Of those, particularly important is the starch-sugar balance. The conversion of starch into sugars in potatoes held at low temperature was found by Müller in 1882.⁽¹⁾ But biochemical and physiological mechanisms of the conversion are not clear.⁽²⁻⁵⁾

Both sucrose and reducing sugar are accumulated in potatoes due to the conversion of starch during low temperature storage and the amount of increased reducing sugar can be over 3% of fresh potatoes by fresh weight.⁽²⁾

These potatoes are not pertinent for processing purpose because of the dark brown color and bitter taste of final products brought about by chemical changes during processing. Potatoes with less than 0.2% of reducing sugar is favorable for processing purpose.⁽⁶⁾

The satisfying storage temperature for the

purpose is about 9 to 10°C, but at the condition, detrimental problems such as weight loss and sprouting are very serious. Therefore, somewhat lower temperature storage is inevitable. The accumulated sugars during storage must be lowered before processing for potato products with high quality. The accumulated sugar could be reduced through reconditioning process⁽⁷⁻⁹⁾ between low temperature storage and processing.

The reconditioning period could be affected by some factors such as the varieties of potato, growing conditions, pretreatments before storage and storage conditions.⁽⁹⁾

The period might be also changed according to portions of a potato because accumulation of sugars varied depending upon portions of a potato and the uneven sugar accumulation resulted in the uneven colored potato chips during processing.⁽¹⁰⁾

In this experiment, to determine the optimum reconditioning period of potatoes stored at dif-

ferent temperature, we tried to study the changes in glucose, fructose and sucrose of halved and whole potatoes after storage and during reconditioning, and to investigate the relationship between reducing sugar content and reconditioning period of halved and whole potatoes.

Materials and Methods

Materials

Potato used in this experiment was Irish cobbler, one of the major varieties of potato in Korea. It was planted in late June at Daekwonryung, Kangwondo and harvested in late September.

The potato plants were sprayed with 0.3% maleic hydrazide at 3 weeks before harvest to inhibit sprouting of potato tubers. Only sound potatoes were selected for the experiment, and their average weight ranged from 90 to 120g.

Storage and reconditioning

Immediately after harvest, potatoes were kept at $15 \pm 1^\circ\text{C}$, RH $89 \pm 3\%$ for 7 days for suberization and then placed for 3 months in 3 rooms of which conditions were $0 \pm 0.5^\circ\text{C}$, $5 \pm 0.5^\circ\text{C}$ and $10 \pm 0.5^\circ\text{C}$ with RH $90 \pm 2\%$, respectively. After storage, potatoes were reconditioned at $20 \pm 1^\circ\text{C}$ and RH $87 \pm 2\%$.

Analysis of sugars

In order to study changes in contents of glucose, fructose and sucrose, potatoes were removed just after three-month storage and at a one-week interval of reconditioning.

For analysis of the sugars⁽¹²⁾ 200g of halved and whole potatoes were sliced and placed in a Waring blender. The samples were covered with 100% ethanol to make the final concentration of 80%(v/v) ethanol. Potato and ethanol were blended at high speed for 5 min. The mixture was then filtered with suction, and the residue was rewashed with 200ml ethanol and then refiltered. The volum of the filtrate from the extract and the washing was reduced to less than 25ml by a rotary vacuum evaporator. The concentrated

Table 1. Conditions of HPLC for analysis of sugars

Instrument	Beckman HPLC(U. S. A.)
Column	Lichrosord RP-NH ₂
Solvent	Acetonitrile: H ₂ O—84 : 16
Flow rate	2.2ml/min., 800psi
Detector	RI (Shodex, SE-11)
Attenuation	X4
Sample size	20 μ l
Recorder	Recording data processor chromopac C-RIA

samples were made up to 25ml with distilled water. For elimination of colorful pigment and small particles, the concentrate was passed through the Sep-pak C₁₈ cartridge (Waters Associate Inc.). The 20 μ l of the decolorized concentrate was injected into HPLC of which conditions for sugar analysis are presented in Table 1.

Results and Discussion

From the analysis of alcohol soluble sugars in potatoes, it was found that glucose, fructose and sucrose were the major sugar. Traces of xylose and maltose were also presented, and they did not change considerably during storage.

The influence of the storage temperature on accumulation of the major sugars are presented in Table 2. Immediately after suberization, there were 0.12% of glucose, 0.08% of fructose and 0.24% of sucrose in the whole potatoes by wet basis. After 3 months storage, sugars in potatoes varied according to the storage temperatures. In potatoes stored at 10°C , significant changes in sugars could not be detected. The sugars were largely built up in potatoes stored at 0°C and 5°C with much larger accumulation at 0°C than at 5°C .

Patterns of sugar accumulation in two portions, apical and basal, of the potatoes were very different, and larger quantity of the sugars was distributed in basal portion of potatoes in all the storage conditions. This trend agreed with the result of Shekher⁽¹⁰⁾ who found the difference in sugar content of the two portions of potatoes sto-

Table 2. Contents of glucose, fructose and sucrose in halved and whole potatoes after suberization and storage
unit : %, fresh wt. basis

Time	Glucose			Fructose			Sucrose		
	Whole	Apical	Basal	Whole	Apical	Basal	Whole	Apical	Basal
After suberization	0.12	0.06	0.18	0.08	0.03	0.13	0.24	0.13	0.30
After storage for 3 months at 0°C	0.95	0.64	1.21	0.87	0.69	1.11	1.25	0.98	1.51
3 months at 5°C	0.60	0.42	0.82	0.57	0.40	0.78	0.82	0.63	1.09
3 months at 10°C	0.12	0.07	0.16	0.10	0.05	0.14	0.26	0.16	0.33

red at 5.5°C for 3 weeks.

Fig. 1 shows the influence of reconditioning period on reducing sugar content of whole potatoes stored at different temperatures for 3 months. Reducing sugar in Fig. 1 was presented as sum of glucose and fructose. Reducing sugar content of potatoes stored at 0°C and 5°C decreased exponentially through reconditioning

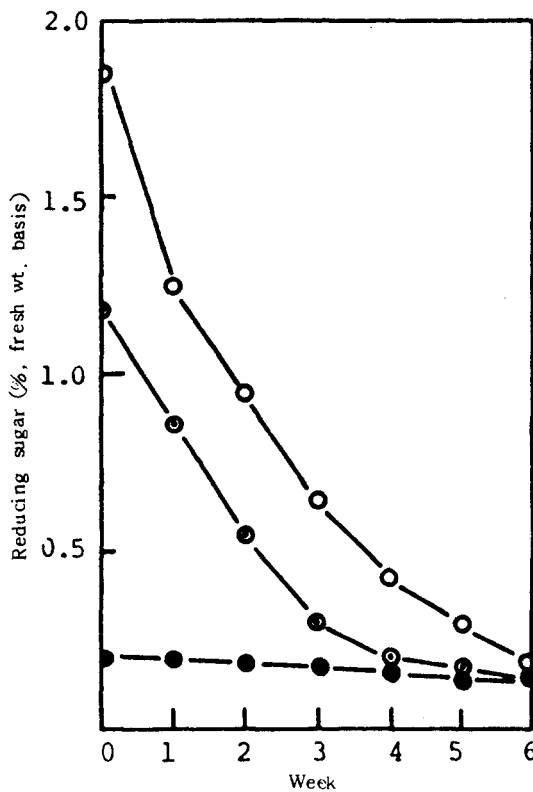


Fig 1. Effects of reconditioning period on reducing sugar content of potatoes stored at different temperatures

- : potatoes stored at 0°C
- ◐ : potatoes stored at 5°C
- : potatoes stored at 10°C

periods, and decrease of the sugar was more rapid for the first week than for the other weeks. After reconditioning for 4 weeks, content of reducing sugar of potatoes stored at 5°C was reduced from 1.2% to 0.2%, and the amount of reduction was smaller than that of potatoes stored at 0°C.

Changes in sucrose contents of whole potatoes through reconditioning period are illustrated in Fig. 2. Sucrose contents of potatoes kept

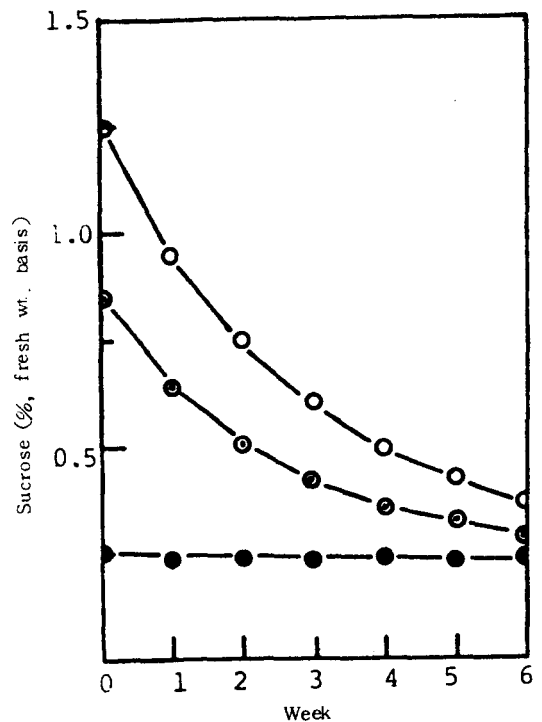


Fig 2. Effects of reconditioning period on sucrose content of potatoes stored at different temperatures

- : potatoes stored at 0°C
- ◐ : potatoes stored at 5°C
- : potatoes stored at 10°C

at 0°C and 5°C were reduced with elapse of reconditioning period. After reconditioning for 6 weeks, sucrose content of potatoes stored at 0°C and 5°C were reduced by 1.8% and 1.1% respectively. However, no detectable change in the sucrose content could be found during reconditioning of potatoes stored at 10°C.

Apical and basal portions of whole potatoes stored at 5°C were analyzed for glucose, fructose and sucrose during reconditioning. The results are presented in Fig. 3 and Fig. 4. Apical and basal portions, amount of sucrose was higher than that of any other sugar during reconditioning period. The contents and decreasing rates of each sugar in basal portion were much higher than those of apical portion, and sucrose disappeared fastest among the sugars in both portions. Reducing sugar content as a sum of glucose and fructose contents in basal portion was

2.5 times higher than that of apical portion after reconditioning for 3 weeks.

Relationships between reducing sugar content and reconditioning period of halved and whole potatoes stored at different temperatures were investigated to estimate the optimum reconditioning period. The relationship between the two factors could be expressed as exponential equation with high correlation coefficient, and it is presented in Table 3. Some researchers reported that reducing sugar in potatoes should be below 0.2% for production of chip with good quality.⁽⁶⁾ Hence, in this point of view, the optimum reconditioning period of whole potatoes stored at 0°C could be estimated about 6 weeks by using the derived equation presented in Table 3. In whole potatoes stored at 10°C, there was a

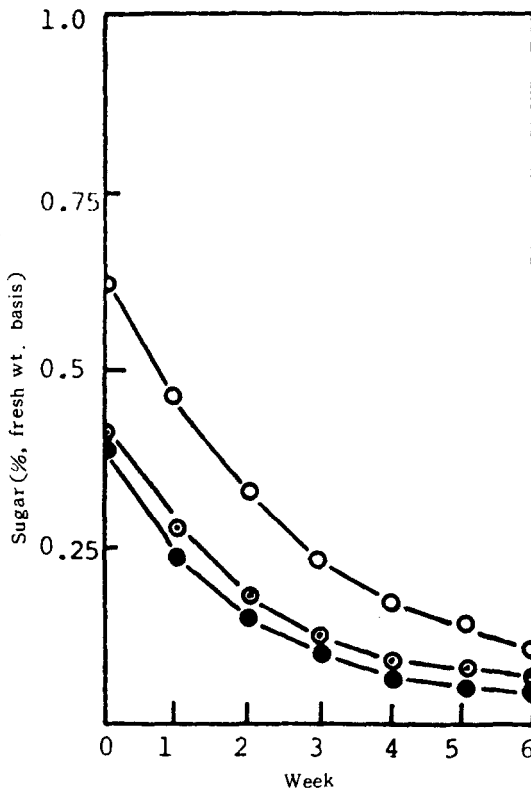


Fig 3. Changes in glucose, fructose and sucrose content in apical portion of potatoes stored at 5°C during reconditioning period

⊙ : glucose
● : fructose
○ : sucrose

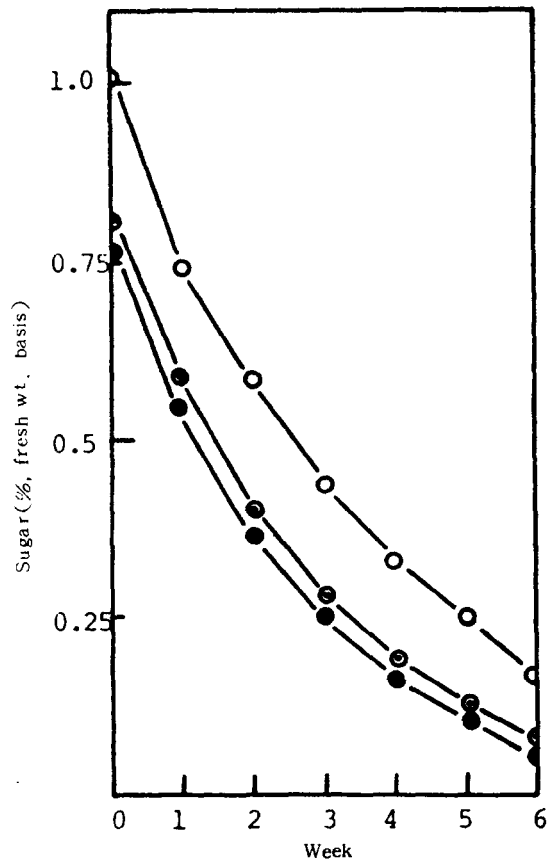


Fig 4. Changes in glucose, fructose and sucrose content in basal portion of potatoes stored at 5°C during reconditioning period

⊙ : glucose
● : fructose
○ : sucrose

Table 3. The relationships between reducing sugar content and reconditioning period of the halved and the whole potatoes at 20°C.

Portion	Storage temp. (°C)	Equation	Correlation coefficient
Whole	0	$Y = 1.779e^{-0.364X}$	0.984
	5	$Y = 1.329e^{-0.433X}$	0.972
	10	$Y = 0.227e^{-0.143X}$	0.979
Apical	0	$Y = 1.256e^{-0.391X}$	0.958
	5	$Y = 0.803e^{-0.443X}$	0.964
	10	$Y = 0.102e^{-1.033X}$	0.962
Basal	0	$Y = 2.200e^{-0.355X}$	0.976
	5	$Y = 1.502e^{-0.366X}$	0.964
	10	$Y = 0.321e^{-0.364X}$	0.902

Y : reducing sugar content (% , fresh wt. basis)

X : reconditioning period(week)

small decrease of reducing sugar during reconditioning period, and reconditioning for 1 week was sufficient for reduction of the sugar to the optimum level for chip processing due to their initial low content of reducing sugar. In consideration of the difference in reducing sugar content between the two portions, the required reconditioning period for apical portion of potatoes stored at 5°C was about 3.2 weeks and 5.6 weeks for basal portion, while whole potatoes stored at the same temperature required about 4.5 weeks of reconditioning period. The required period in this experiment was shorter than the result of Aoki *et al.*⁽¹³⁾ who kept potatoes at 5°C for 8 months and reconditioned the potatoes at 15-17°C. When potato chip was produced with the whole potatoes stored at 5°C and reconditioned only 4.5 weeks, the chip might have a unfavorable and uneven quality caused by higher reducing sugar content of basal portion than the optimum level for processing. Hence, for the elimination of this problem, potatoes should be sufficiently reconditioned until the amount of reducing sugar of basal portion decreases to the optimum level for processing.

From this point, it could be concluded that the required optimum reconditioning periods were 1.3 weeks, 5.6 weeks and 9.4 weeks for potatoes stored at 10°C, 5°C and 0°C, respectively.

요 약

저온 저장한 감자의 가공적성을 향상시키기 위한 일련의 실험으로 0°C, 5°C 및 10°C에서 감자(남작)를 3개월간 저장한 후 20°C에서 reconditioning을 행하면서 reconditioning기간에 따른 감자의 glucose, fructose 및 sucrose의 함량변화를 조사하였다.

이들 당류중 sucrose가 감자에 다량 함유되어 있으며 reconditioning기간 경과에 따라 가장 신속하게 그 함량이 감소되었다. 저온 저장한 감자의 reconditioning기간과 환원당 함량의 관계는 지수함수 관계로 나타낼 수 있었으며, 감자의 basal부위가 apical 부위보다 장기간의 reconditioning기간이 소요되었는데 감자부위에 따른 환원당의 함량차이를 고려할때 0°C, 5°C 및 10°C에서 저장한 감자의 적정 reconditioning기간은 각각 9.4주, 5.6주 및 1.3주인 것으로 조사되었다.

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- (Received November 30, 1984)