Effect of Low-Temperature Storage on Some Properties of Potato Starch

Naomy S. SABINIANO*, Ken-ichi ISHIBASHI** and Kazunori HIRONAKA**

* *Institute of Food Science and Technology, University of the Philippines at Los Banos, Laguna, Philippines*
** *Department of Bioresource Chemistry, Obihiro University of Agriculture and Veterinary Medicine, Inada-cho, Obihiro-shi, Hokkaido 080, Japan*

This study was conducted to determine the effect of storage on the properties of potato starch. Starch was prepared from three varieties of potato, namely ; Benimaru, Toyoshiro and Konafubuki, after storage at 5℃ for 6 months. The average granule size, phosphorus content, Brabender peak viscosity and breakdown of the starches from the stored tubers for each variety were lower than those from the unstored tubers. The initial pasting temperature did not have a considerable change. The temperature at peak viscosity of Benimaru starch increased, while it decreased for both Toyoshiro and Konafubuki starches after storage. The viscosity and rigidity of 1% starch pastes also decreased during storage while the blue value increased. The decrease in Brabender peak viscosity and breakdown were closely correlated with phosphorus content ($r=0.96^{**}$ and 0.93^{**}, respectively).

In Japan, potato starch is utilized in a large number of various products such as noodles, kamaboko and jellies. The usefulness of starch in these products depends on its chemical composition and physicochemical properties, which are in turn dependent on a number of factors. These include genetic, climatic, soil, meteorological and technological factors which vary in every country and in a particular period of time. Technological factors include post-harvest handling and the method of starch preparation.

Reports in the literature prior to this study indicated that starch properties change during potato storage. Changes were noted in granule size and appearance, amylose content, viscosity, reducing power, as well as in phosphorus, potassium and calcium contents[2)~8)]. However, this subject had not been studied extensively in Japan. This study was therefore, initiated to determine the effect of storage on the properties of starches from potatoes produced in Hokkaido, Japan.

Materials and Methods

Samples and storage condition

The potatoes (Benimaru, Toyoshiro and Konafubuki varieties) were obtained from Kawanishi Agricultural Cooperatives, Obihiro, in October 1991. Each variety was divided into two lots, one for the control (unstored) and the other for storage at 5℃ for 6 months.

Starch preparation

Starch was prepared from the tubers according to the method of YAMAMOTO[9)] as shown in Fig. 1. Purified starches were kept in airtight polyethylene bottles until analyses.

Chemical composition and physicochemical properties

Starches from unstored tubers were analyzed for moisture, crude protein and ash contents according to standard methods[10)]. The crude fat content was determined following the method of TSUTSUMI[11)]. Granular size distribution was determined by a light transmission method using a particle size analyzer (Seishin Kogyo, SKN 500).

Blue value was measured as the absorbance at 680 nm of 4 mg starch in 100 m*l* dilute I_2-KI

solution according to KOBAYASHI[12]. Phosphorus content was determined using the vanado-molybdate method of TAKAGI[13].

The behavior of starch during heating was determined using a Brabender Viscograph AM-3 (Brabender OHG, Duisberg, Germany). The bowl speed was 75 rpm with the 700 cmg torsion spring ; 4% starch solution was used. The starch suspension was heated at the rate of 1.5℃ per min until 92.5℃ and held at that temperature for 30 min.

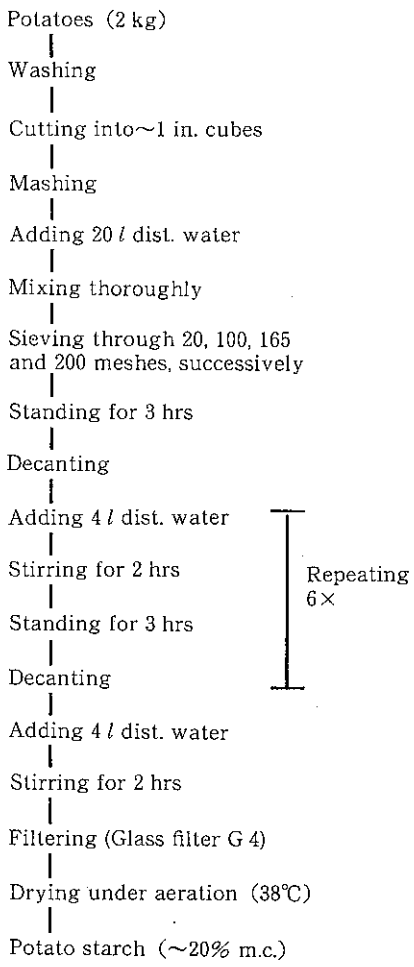

Fig. 1 Starch preparation from potato

The viscosity and rigidity of starch pastes (1, 2, 3 and 4%) were also determined at 20℃ using a coaxial cylindrical rheometer as described by HIRONAKA *et al.*[14]. However, the instrument was found to be applicable only to 1% starch paste solutions since at higher concentrations unreproducible data were obtained.

All determinations were done in duplicate except for the granular size distribution.

Results and Discussion

Chemical composition

The chemical compositions of the starches from the three potato varieties (Table 1) showed no distinct differences in terms of crude protein, crude fat and ash contents.

Effect of storage on granule size of starch

The granular size distributions of the starches are shown in Table 2. Benimaru has the biggest average granule size at 35.75 μm, followed by Konafubuki at 35.00 μm and Toyoshiro was the smallest at 32.50 μm. Storage at 5℃ for 6 months caused a little decrease in the average size of the granules - Benimaru (2.1%) ; Toyoshiro (1.54%) and Konafubuki (1.29%). Granules less than 20 μm in of the three varieties increased after storage while larger granules (>50 μm) decreased. Changes in the granule sizes between 20 and 50 μm were different for each variety.

MICA[6] reported that during storage at lower temperatures, larger granule were degraded to smaller ones, thereby, increasing the latter's share. GOLACHOWSKY[8] found that granules > 35 μm decreased and granules <20-30 μm in

Table 1 Chemical composition of starch from different potato varieties

Composition (d.b.)	Benimaru	Toyoshiro	Konafubuki
Crude protein (%)	0.012±0.001	0.015±0.001	0.013±0.002
Crude fat (%)	0.060±0.010	0.064±0.001	0.060±0.004
Ash (%)	0.240±0.010	0.280±0.015	0.280±0.000

Mean value ± standard deviation for 2 replications.

Table 2 Distribution percentages of granular sizes of potato starches stored at 5℃ for 6 months

Sample	Storage period (months)	Range of granular size (μm)					Average (μm)
		<20	20-30	30-40	40-50	>50	
B	0	7.70	28.63	23.46	17.59	22.62	35.75
	6	13.31	23.30	28.28	16.78	18.33	35.00
T	0	15.10	31.78	20.53	17.60	14.99	32.50
	6	16.61	28.39	25.11	16.14	13.69	32.00
K	0	7.12	29.82	27.01	15.79	20.70	35.00
	6	10.31	20.58	24.70	28.32	20.59	34.55

B=Benimaru ; T=Toyoshiro ; K=Konafubuki.

diameter, increased after storage for 12 weeks at various temperatures (−15 to+20℃). However, JOHNSTON *et al.*[4] found no significant difference in the granule size distribution during potato storage at 2℃. The present results agreed approximately with the findings of MICA[6] and GOLACHOWSKY[8].

Changes in blue value

In Table 3, it can be observed that Konafubuki had the lowest blue value (0.379) compared with Benimaru (0.423) and Toyoshiro (0.414). After storage at 5℃ for 6 months, the blue value of the starches from each variety increased. There is no data on the literature regarding changes in the blue value of potato starches during storage. However, blue value and amylose contents have an excellent linear correlation, such that it can be considered to be a measure of amylose. GOLACHOWSKY[8] reported that amylose content did not change during potato storage at 4℃ but decreased during storage at 8, 20 and 0℃. On the other hand, JOHNSTON *et al.*[4] reported that the amylose-amylopectin ratio of potatoes increased during storage at 2℃.

Changes in phosphorus content

As shown in Table 4, Konafubuki had the highest phosphorus content (814.92 ppm), followed by Toyoshiro (779.44 ppm) and lastly by Benimaru (662.46 ppm). After 6 months storage at 5℃, the phosphorus content of starches from each variety decreased. The same result was observed by GOLACHOWSKY[8] during potato storage from −15 to +20℃.

Table 3 Blue value of starches from potato tubers stored at 5℃ for 6 months

Variety	Blue value	
	Unstored	Stored
Benimaru	0.423±0.015	0.540±0.050
Toyoshiro	0.414±0.065	0.437±0.010
Konafubuki	0.379±0.080	0.423±0.075

Mean value±standard deviation for 2 replications.

Table 4 Phosphorus contents of starches from potato tubers stored at 5℃ for 6 months

Variety	Phosphorus content (ppm)	
	Unstored	Stored
Benimaru	662.46±3.27	564.25± 1.06
Toyoshiro	779.44±4.72	673.92±20.93
Konafubuki	814.92±3.54	717.50±12.96

Mean value±standard deviation for 2 replications.

However, MICA[7] found an increase in the phosphorus content of starch from tubers stored for 6 months at 10℃ while SCHWIMMER *et al.*[16] did not find any change during storage at 4.4 and 10℃ for 18 weeks.

Viscoamylographic properties

The Brabender amylograms of the starches are shown in Figure 2. There was no considerable change in the initial pasting temperature

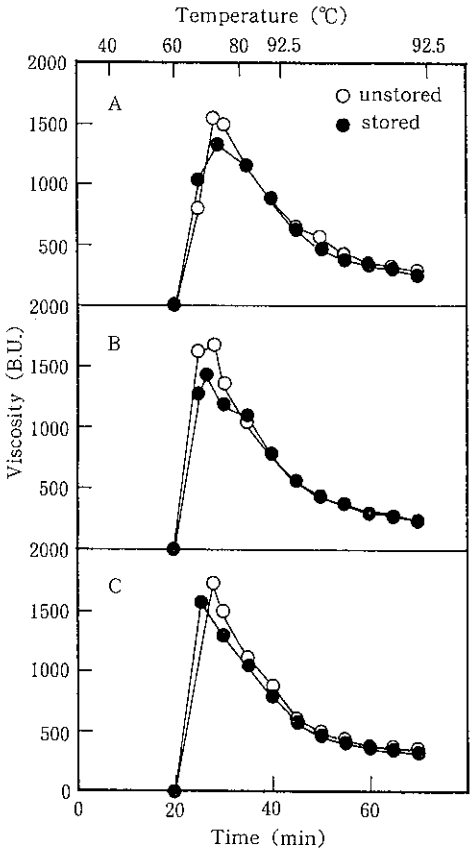

Fig. 2 Brabender viscoamylograms of starches from three varieties of potato a) Benimaru, b) Toyoshiro and c) Konafubuki stored at 5℃ for 6 months

of the starches from the stored tubers for each variety. The temperature at peak viscosity of Benimaru starch increased after storage at 5℃ for 6 months. However, for Konafubuki and Toyoshiro starches the temperature at peak viscosity decreased. The same trend was observed by GOLACHOWSKY[8] for potatoes stored at 8℃ and by YAMAMOTO[17] during storage of Konafubuki for 6 months at 6℃. The peak viscosity of starches from all varieties considerably decreased during storage but no distinct decrease was observed for the final viscosity except for Konafubuki variety.

Phosphorus content was positively correlated with the viscosity of starch pastes[2]. This relationship is due to the close orientation of phosphate ions in potato starch which gives rise to the electrostatic repulsion that helps expand the amylopectin molecules, promoting their hydration and the consequent high viscosity[18]. Thus, the decrease in viscosity of the starches from stored tubers found in this study can be explained by the decrease in phosphorus content. WHISTLER and PASCHALL[19] also mentioned that potato starch undergoes a very rapid and exceptionally high swelling at relatively low temperatures indicating weak internal bonding which is partly due to the presence of ionizable esterified phosphate groups. In this study, a high correlation of peak viscosity and breakdown with the phosphorus content was also found ($r=0.96^{**}$ and 0.93^{**}, respectively).

Viscoelasticity of starch pastes

The viscosity and rigidity of 1% starch pastes were also measured using a coaxial cylindrical rheometer. It can be observed from Tables 5 and 6 that the viscosity and rigidity of

Table 5 Viscosity of 1% starch pastes from potato tubers stored at 5℃ for 6 months

Variety	Viscosity (poise)	
	Unstored	Stored
Benimaru	44.05±4.13	11.32±0.01
Toyoshiro	53.98±2.30	28.43±0.22
Konafubuki	36.25±2.90	24.36±0.37

Mean value±standard deviation for 2 replications.

Table 6 Rigidity of 1% starch pastes from potato tubers stored at 5℃ for 6 months

Variety	Rigidity (dyn/cm^2)	
	Unstored	Stored
Benimaru	21.46±1.175	3.68±0.14
Toyoshiro	31.85±1.10	5.76±0.10
Konafubuki	13.17±0.015	5.27±1.13

Mean value±standard deviation for 2 replications.

the starch pastes from stored tubers of each variety were lower compared with the unstored tubers. This result further supports the data obtained by Brabender amylography.

References

1) LISINSKA, G. and LESCZCZYNSKI, W. : Potato Science and Technology (Elsevier Science Publ. Co. Inc., New York), p.137, 303 (1987).
2) WINKLER, S. : *Die Starke*, **13**, 319 (1961).
3) SAMOTUS, B. and SCHIWIMMER, S. : *Plant Phsio.*, **37**, 519 (1962).
4) JOHNSTON, F.B., URBAS, B. and KHANZADA, G. : *Am. Potato J.*, **45**, 315 (1968).
5) ISHERWOOD, F.A. : *Phytochemistry*, **12**, 2579 (1973).
6) MICA, V.B. : *Starch*, **27**, 181 (1975).
7) MICA, V.B. : *Starch*, **28**, 410 (1976).
8) GOLACHOWSKI, A. : *Starch*, **37**, 263 (1985).
9) YAMAMOTO, K. : Bareisho denpun no riyou tokusei ni kansuru kenkyu. Ph. D. Thesis (Hokkaido University, Japan) (1984).
10) AOAC : Official Methods of Analysis, 14 th ed. Association of Official Analytical Chemists, Washington, D.C. (1984).
11) TSUTSUMI, T. : Denpun Kagaku Jikken Ho, SUZUKI, S. and NAKAMURA, D., Eds. (Asakura Shoten, Tokyo), p.49 (1979).
12) KOBAYASHI, T. : Denpun Handbook, NIKUNI, J., Ed. (Asakura Shoten, Tokyo), p.238 (1961).
13) TAKAGI, Y. : Seikagaku ryouiki Niokeru Koden Hishoku Ho, (Nankodo, Tokyo) (1964).
14) HIRONAKA, K., SHINDOH, T. and ISHIBASHI, K. : *Nippon Shokuhin Kogyo Gakkaishi*, **36**, 891 (1989).
15) MORRISON, W.R. and LAIGNELET, B. : *J. Cereal Sci.*, **1**, 9 (1983).
16) SCHWIMMER, S., BEVENUE, A., WESTON, W.J. and POTTER, A.L. : *J. Agric. Food Chem.*, **2**, 1284 (1954).
17) YAMAMOTO, K. : Denpun Gakkai Hokkaido Shibu 20 Shunen Kinen Shi, p.32 (1989).
18) NUTTING, G.C. : *J. Colloid Sci.*, **7**, 128 (1951).
19) WHISTLER, R.L. and PASCHALL, E.F. : Starch Chemistry and Technology, vol. 1, Fundamental Aspects (Academic Press, New York) (1965).

(Received Oct. 20, 1993)

バレイショ澱粉の諸性状におよぼす低温貯蔵の影響

サビニアノ S. ナオミ*・石橋憲一**・弘中和憲**
*フィリピン大学食品科学工学科
**帯広畜産大学生物資源化学科

三品種のバレイショ（ベニマル，トヨシロ，コナフブキ）を用い，収穫直後と5℃で6カ月貯蔵後のものから調製した澱粉の諸性状におよぼす貯蔵の影響を調べた．その結果，6カ月貯蔵後のバレイショより調製した澱粉の平均粒径，リン含量，ブラベンダー最高粘度およびブレークダウンは収穫直後のものより低かった．また，糊化開始温度は貯蔵の影響をほとんど受けないことが分かった．ベニマル種の澱粉の最高粘度に達する温度は貯蔵により上昇するが，トヨシロとコナフブキのそれは低下した．1% 澱粉溶液の粘性および弾性は貯蔵とともに減少したが，青価は増加した．ブラベンダー最高粘度およびブレークダウンとリン含量との間には，それぞれ高度の相関が認められた．