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Changes of Starch Properties during Steeping of Potato

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Abstract

It is a unique dietary culture in Korea in that starch is isolated and utilized from steeped potato. In this experiment the potato was steeped in water at 30 °C for 7 days and the properties of starch were examined. The pH in steep water decreased, while sugar cotent (total and reducing) increased. The lager granules were diminished during steeping. Holes on the starch granules were observed from the second days of steeping. The density, amylose content, phosphorus and lipid content were decreased. Relative crystallinity of starch reached the highest value at 4th day of steeping and decreased thereafter. The changes in enthalpy of gelatinization were similar. Starch was resistant to acid or enzymatic hydrolysis and showed lower values for swelling power and amylograph viscosities.

Kew words: potato starch, steeping of potato

Introduction

Potato in Korea has mainly been cultivated for the fresh pack market. The production of starch from potato in Korea is only fragment due to competition of corn and/or sweet potato starch[1].

It has long been a unique dietary culutre in Korea in that starches from potato, arrowroot, acorn and other plants have been extracted and utilized as an emergency food. Too small, mishappen or damaged potato is steeped in water to isolated starch (or flour). However, no investigations concerning the effect of steeping of potato on the properties of starch or flour have been reported.

This study was undertaken to investigate the changes in properties of starch isolated during steeping of potato in water.

Materials and Methods

Material

Potato (Superior cultivar) was obtained from Administration of Rural Dvelopment, Suwon, Korea, with in 10 days from harvest.

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Steeping of potato

Potato was washed to remove dirts, put into a glass bottle with distilled water, sealed and kept at 30 °C for 7 days.

The changes of pH and sugar content in steep water were measured. The total and reducing sugars were determined by phenol-sulfuric acid method[2] and Somogyi method[3], respectively.

Isolation of starch

Potato was peeled, sliced, blended for 1 min, with Waring blendor and sieved with 70 and 140 mesh sieves. The precipitate was treated with 0.2% sodium hydroxide solution and washed to neutral with distilled water. The starch was dried at room temperature for 2 days and passed through a 100 mesh sieve.

Analysis of starch

Proximate composition and phosphorus were determined by a standard procedure[4]. Lipid content after extraction with methanol for 24 hr at 85 °C was termed bound lipid.

The shape and size of starch granule were observed with light and scanning electron microscope. The density was measured with xylene replation method[5]. Blue value was determined according to the method of Gilbert and Spragg[6]. Amylose content was estimated by the method of Williams *et al.*[7], with a standard curve prepared from potato amylose and amylopectin. Water-binding capacity was measured following the method of Medcalf and Gilles[8]. Relative crystallinity was estimated from X-ray diffraction pattern[9]. The swelling power and solubility were measured at 80°C[10].

Measurement of gelatinization properties

Differential scanning calorimetry was carried out with water-to-starch ratio of 2.0 and heating rate of 10°C/min. The pasting property of starch (3%, d.b) in 500 m*l* was followed with Brabender/visco/Amylograph[11].

Hydrolysis of starch

Lintnerization of starch was conducted with 2.2 N hydrochloric acid for 48 hr at 35°C[12]. Starch (160 mg) was dispersed in 38.5 m6 of 0.1 M acetate buffer (pH 4.3) for 30 min at 37°C, added 1 m*l* of glucoamylase (AMG 300L, Novo Co., Denmark) and reacted for 60 min at 37°C. After centrifugation of the mixture at 3000 g for 10 min, the sugar content of the supernatant was determined with the phenol-sulfuric acid[2] and the degree of hydrolysis was calculated.

Result

pH and sugar content in steep water

pH of the steep water decreased during steeping, with sharp decrease during the first two days (Table 1). The total sugar content at the first day of steeping was 6.3 μg/m*l* which was increased by 20-fold at the second day, after which consistently increased by approximately 30 μg/m*l* per day. The free sugar also increased but decreased at the end of steeping (Table 1).

Table 1. Changes in pH and sugar content in steep water during steeping of potato

Steeping time (day)	pH	Total sugar (μg/ml)	Reducing sugar (μg/ml)
0	6.60	—	—
1	5.98	6.3	0.7
2	5.47	119.5	14.3
3	5.47	144.7	20.3
4	5.44	176.1	25.3
5	5.41	208.9	28.7
6	5.31	239.1	35.9
7	5.20	272.1	21.5

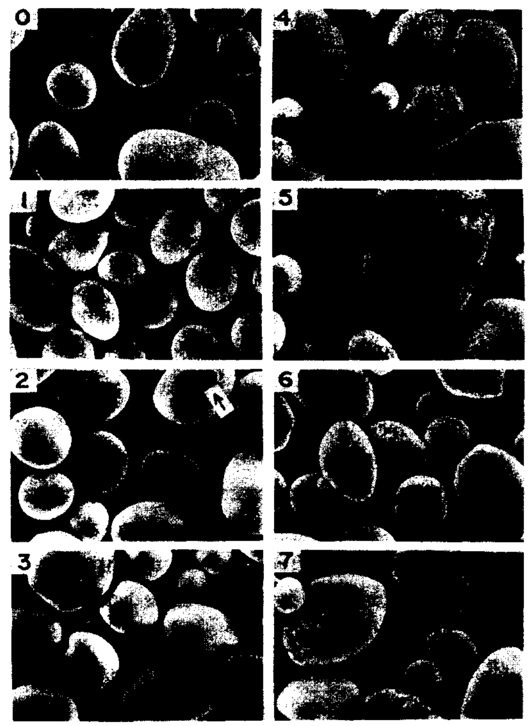

Fig. 1. Scanning electron micrographs of starch granules. Arrow indicates hole and the number is the steeping time (day).

Starch granule

Scanning electron micrographs of starch granules showed some holes from the second day of steeping, which was more pronounced as steeping progressed (Fig. 1). However, loss of birefr-

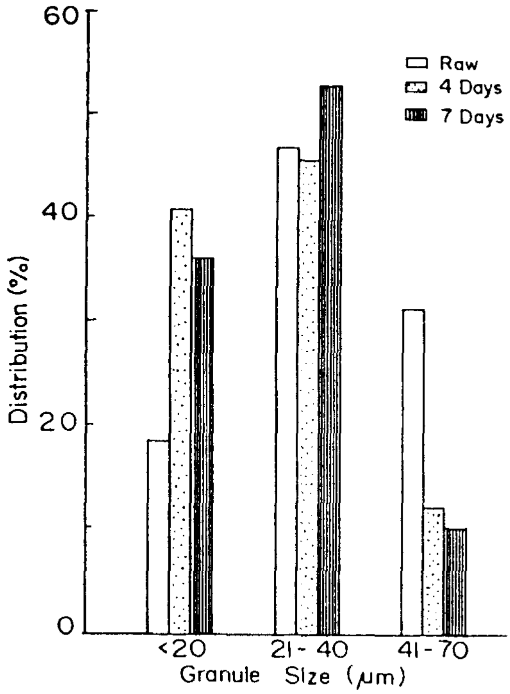

Fig. 2. Distribution of starch granules during steeping of potato

ingence was not observed throughout the steeping time.

The size of starch granules ranged 10 to 70 μm, with average being 35 μm. The larger granules progressively diminshed during steeping (Fig. 2). The granules with size of 61-70 μm decreased from 10.5% to 1.4% after one day of steeping and were essentially absent thereafter.

The density of starch also decreased from 1.55 to 1.30 g/cc after three days of steeping and continued to decrease to 1.19 g/cc at the end of steeping.

Physicochemical properties of starch

Proximate composition and some physicochemical data of starch are tabulated in Table 2. Protein content remained constant. Ash content increased while phosphorus decreased during steeping. The lipid content decreased from 0.10% to 0.02% after three days of steeping but again increased to 0.09% at the end of steeping. The bound lipid however consistently increased.

The absorbance of starch-iondine complex shifted to lower wavelength and the bule value and amylose content decreased with the increase of steeping time (Table 2). Water-binding capacity increased. Relative crystallinity increased up to 4 days of steeping and then decreased. The swelling power decreased from 140 to 124 after 1 days of steeping which remained relatively constant up to 4 days and decreased (Table 3). The solubility showed the similar trend to that of swelling power.

Gelatinization properties

The DSC transition temperature changed at 5 days of steeping, while the enthalpy of gelatinization (ΔH) increased during 4 days and decreased thereafter (Table 4).

Amylograph indices indicate that the initial pasting temperature significantly increased after 5

Table 2. Proximate composition and some physicochemical data of starch

Steeping time (day)	Crude protein (%)	Ash (%)	Crude lipid (%)	Bound lipid (%)	Phosphorus (%)	λ_{max} (nm)	Blue value	Amylose content (%)	Water binding capacity (%)	Relative crystallinity (%)
0	0.22	0.20	0.10	0.10	0.057	603	0.344	19.3	93	32.1
1	0.22	0.22	0.06	0.10	0.046	601	0.316	15.3	103	32.5
2	0.22	0.22	0.03	0.11	0.046	601	0.312	14.9	105	33.4
3	0.22	0.22	0.02	0.12	0.043	600	0.300	14.6	107	34.8
4	0.22	0.25	0.02	0.20	0.043	600	0.300	14.0	126	35.5
5	0.22	0.25	0.02	0.21	0.040	600	0.297	13.6	138	33.3
6	0.22	0.26	0.08	0.29	0.031	599	0.294	13.3	142	33.3
7	0.22	0.26	0.09	0.39	0.011	598	0.288	13.1	144	33.3

Table 3. Swelling power and solubility of potato starch at 80°C

Steeping time (day)	Swelling power	Solubility (%)
0	140	31
1	124	30
2	122	28
3	121	28
4	120	28
5	81	22
6	79	19
7	79	17

Table 4. DSC transition temperature of starch

Steeping time (day)	Onset temperature (°C)	Conclusion temperature (°C)	ΔH (cal/g)
0	62.8	77.7	4.15
1	63.0	77.7	4.16
2	62.7	77.7	4.38
3	62.7	77.7	4.54
4	62.8	78.4	4.94
5	63.3	79.8	4.38
6	63.1	79.1	4.11
7	63.7	79.8	4.18

Table 5. Amylograph indices of starch (3% d.b)

Steeping periods (day)	Initial pasting temp.[a] (°C)	Peak height (B.U.)	Temp. at peak height (°C)	Viscosity at 94.5°C (B.U.)	After 15 min. height[b] (B.U.)	Peak height at 50°C(B.U.)
0	66.0	1,010	84	850	580	510
1	66.0	1,040	85.5	840	600	560
2	67.5	920	94.5	900	620	580
3	67.5	820	94.5	800	680	540
4	69.0	780	94.5	640	710	680
5	79.5	—	—	210	420	520
6	84.0	—	—	220	380	475
7	84.0	—	—	120	180	240

a) Temperature at which the initial rise in the curve reached 10 B.U.
b) peak height after 15-min holding at 94.5°C.

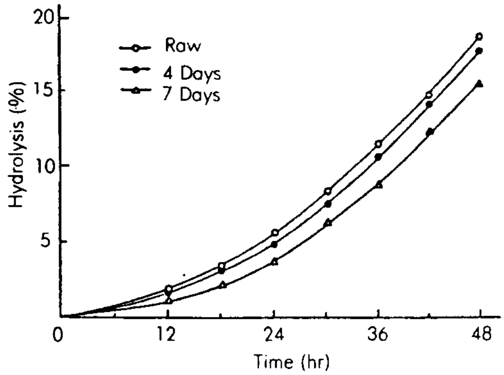

Fig. 3. Changes in degree of hydrolysis of starch in 2.2N HCl at 35°C.

day of steeping, at which no peak viscosity was observed (Table 5). Hot and cold paste viscosities of starches of steeping times of 5-7 days were considerably lower than those of 0-4 days.

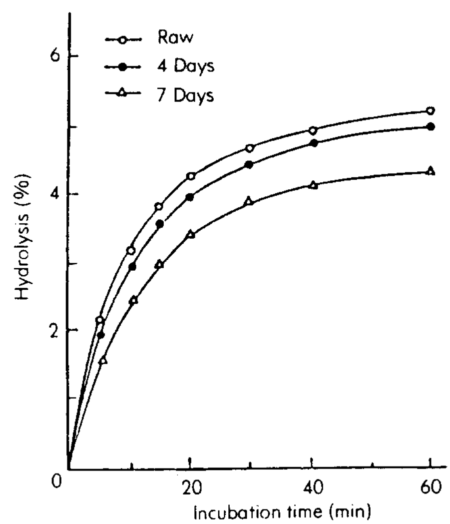

Fig. 4. Changes in hydrolysis of starch by glucoamylase at 37°C.

Degree of hydrolysis

The degree of hydrolysis by acid (Fig. 3) or enzyme (Fig. 4) decreased with the increase of steeping time.

Discussion

It is known[13] that starch granules show holes when digested with amylases, and that granule birefringence is not greatly affected during the initial stages of enzyme digestion. The increase of total and reducing sugars in the steep water (Table 1) and occurrentce of holes in the starch granules (Fig. 1) strongly suggest that enzyme hydrolysis of starch is operative during steeping of potato. The disappearance of large starch granules (Fig. 2) and decrease of density, phosphorus and amylose content (Table 2) also support the possiblity of enzym eaction on starch. The occasional explosion of sealed glass bottle during steeping of potato was observed in the preliminaly experiment, which imply that the enzyme activity may be due to respiration of potato.

The increase of relative crystallinity of starch during steeping for 4 days (Table 2) indicates the hydrolysis of amorphous region of the starch granule. However, the decrease of crystallinity after 5 days of steeping may imply the partial hydrolysis of crystalline region. It was reported[14] with subsequent controlled-heat treatments of waxy corn by DSC that a noncrystalline transition proceeded the main crystalline melt of the starch. The data of DSC in that the enthalpy of gelatinization increased to reach the highest value after 4 days of steeping and then decreased (Table 4) are agreed with the changes of crystallinity of starch (Table 2). The lipid content of potato starch does not affect the enthalpy of gelatinization[15].

Since the prolonged hydrolysis of starch with mineral acid occures in two distinct stages, *i.e.*, a relatively fast hydrolysis of the amorphous phase and a slower degradation of the crystallities[12,16], the resistance of acid degradation of starch isolated from steeped potato (Fig. 3) supports the DSC data.

Unde the experimental conditions it seems that the significant changes in structure of potato starch occures between 4 and 5 days of steeping. These are reflected in relative crystallinity (Table 2), swelling power (Table 3) and amylograph viscosities (Table 5).

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감자의 썩힘 중 녹말의 성질 변화

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감자를 물에 침지시켜 썩히고 전분을 분리 이용하는 것은 우리나라 특유의 식문화이다. 본 실험에서는 감자를 30℃의 물에 7일간 침지시키면서 전분의 성질 변화를 조사하였다. 침지 중 큰 입자(61-70 μm)는 침지 1일에 크게 감소하였고 침지 2일 이후에는 거의 존재하지 않았으며, 전분입자는 침지 2일부터 구멍을 보이기 시작하였다. 침지 중 수침액의 pH는 감소하였고, 총당과 환원당은 증가하였다. 전분입자의 밀도, 아밀로오스 함량, 인 함량 및 지방질 함량은 감소하였다. 전분의 상대결정도는 증가하여 침지 4일에서 가장 높았고 다시 감소하였다. 호화엔탈피의 변화도 비슷한 결과이었다. 침지전분은 산 또는 효소에 의한 가수분해 정도가 낮았고, 팽윤력, 아밀로그라프의 점도 등도 낮았다.