KOREAN J. FOOD SCI. TECHNOL.
Vol. 10, *No.* 2(1978)

Physicochemical Properties of Tongil(Indica type) and Paldal (Japonica type) Rice Starch

by

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(Received February 23, 1978)

통일 및 팔달쌀 전분의 이화학적 성질에 관한 연구

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(1978년 2월 23일 수리)

Abstract

Physicochemical properties of rice starches from Paldal(japonica type) and Tongil(indica type) were investigated. There were no significant differences in water-binding capacity, blue value and amylose content between the two starches. Paldal starch showed a higher value for swelling power than Tongil starch. Amylograph data showed that both Paldal and Tongil starches had similar paste viscosities except setback in which Tongil starch showed a higher value. No significant differences were observed for intrinsic viscosity and glucose units per segment between Paldal and Tongil amylopectin fractions. However, the intrinsic viscosity for Tongil amylose was considerably higher than Paldal amylose. The rate of retrogradation of Tongil starch gels at 21°C was faster than Paldal starch gels.

Introduction

Tongil rice variety, a cross of IR-8(indica), TN-1 (Taiwan short indica) and Yukara(japonica), was introduced in 1971 as a high-yielding new variety. Ever since its release several workers have investigated such aspects of Tongil rice as cooking quality.[1,2] milling properties,[3] and preservability.[4,5]

Although it is generally recognized[1] that Tongil rice exhibits poorer palatability than traditional japonica cultivars common in Korea, little attention has been given to the starch which is the most important constituent of rice that affects the cooking quality. Kim *et al.*[1] and Chung and Lee[6] reported some properties of the Tongil rice starch including blue value, alkali number, amylose content and gelatinization temperature. Their results showed that Tongil starch had a somewhat higher amylose content than traditional rice starch and showed characteristics similar to those of indica type rice.

The purpose of this study was to investigate the physicochemical properties and to examine the kinetics of retrogradation of rice starches from Tongil(indica) and Paldal(japonica).

Materials and Methods

Materials: Two rice varieties, Tongil and Paldal, harvested in 1975 were obtained from the Office of Rural Development, Suwon, Korea. The rice paddy was dehulled, milled and ground to pass through a 60-mesh sieve.

Starch Preparation: The rice flour was suspended in distilled water, blended for 5 min in a Waring blendor and centrifuged at 3,000 x g for 10min. The starch at the bottom of centrifuge tube was recovered and reslurried in distilled water followed by centrifugation. The starch was then suspended in 0.2% NaOH solution, stored at 4°C overnight and the supernatant was decanted the following day. The alkali treatment was repeated until no yellow layer appeared after centrifugation. The starch recovered was washed with water until neutral, air-dried and passed through an 80-mesh sieve.

Physicochemical Analyses: Blue value and amylose content were determined by the methods of McCready and Hassid.(7) Water-binding capacity was measured with the procedure of Medcalf and Gilles.(8) The swelling power over a range of temperatures was determined according to the procedure of Schoch.(9) Pasting properties were examined with the Brabender Amylograph using 40g starch (db) in 450ml distilled water.(10)

Starch Fractions: Prior to fractionation, the starch was defatted with methanol in a Soxhlet extractor for 24hr, air-dried and passed through an 80-mesh sieve. The starch was fractionated into amylose and amylopectin following the procedure of Montgomery and Senti.(11) Amylopectin was oxidized with sodium metaperiodate using the procedure of Shasha and Whistler.(12) Intrinsic viscosity for amylose and amylopectin was determined at 25°C, using an Ubbelohde viscometer.(13)

Aging of Starch Gels: Starch gels were prepared to give a 45% concentration of starch on a dry basis.(14) The gels were cooled for 20min at room temperature before storage. At 0, 1, 2, 3 and 5 days, the hardness of the gels stored at 21°C was examined using a Texturometer(General Food Co., U.S.A.). The limiting modulus was obtained from the gels stored at 2°C for 6 days. The hardness data were analyzed according to the Avrami equation as described previously.(14)

Other Analyses: AACC official methods(15) were utilized for moisture, ash and protein determinations.

Results and Discussion

Chemical and physicochemical data on the two rice starches are given in Table 1. Both Paldal and Tongil starches had similar values for water-binding capacity and blue value.

Data on swelling power over a range of temperatures are shown in Table 2. The swelling power value for Paldal starch was higher than Tongil starch at all temperatures examined. Since the bonding forces within the starch granule would influence the nature of swelling,(16) a highly associated starch with an extensive and strongly bonded micellar structure should be relatively resistant toward swelling. The results in Table 2 thus imply that the bonding forces within the granule of Tongil starch are stronger than in the Paldal starch. These results may be in line with the findings of Han *et al.*(5) and Hwangbo *et al.*(2) who reported that the mechanical hardness of Tongil was higher than a japanica type Jinheung rice variety.

Table 1. Chemical and physicochemical data on rice starch

	Paldal	Tongil
Moisture (%)	9.7	9.2
Ash (%)	0.17	0.14
Protein (%)	0.1	0.1
Water-binding capacity(%)	134.0	132.0
Blue value	0.28	0.29

Table 2. Swelling power of rice starch

Starch	Swelling power at			
	50°C	60°C	70°C	90°C
Paldal	2.47	3.39	8.69	15.16
Tongil	2.27	3.20	7.89	12.66

An amylograph curve for Tongil and Paldal starch is shown in Fig. 1. Results of starch paste viscosities are given in Table 3. Both starches had the same

Table 3. Data on rice starch paste viscosities

Starch	Initial pasting temperature (°C)	Peak height (BU)	Height at 95°C (BU)	15-min hold height (BU)	Height at 50°C (BU)
Paldal	64.0	>1,000	510	360	750
Tongil	63.5	990	520	365	830

Table 4. Physicochemical properties of rice starch

Starch	Amylose		Amylopectin			Time constant of starch gels at 21°C(days)
	Content (%)	Intrinsic viscosity [η]	Branching (%)	Glucose units per segment	Intrinsic viscosity [η]	
Paldal	19.0	1.63	4.5	22	1.85	10.64
Tongil	19.5	2.05	4.7	21	1.73	8.86

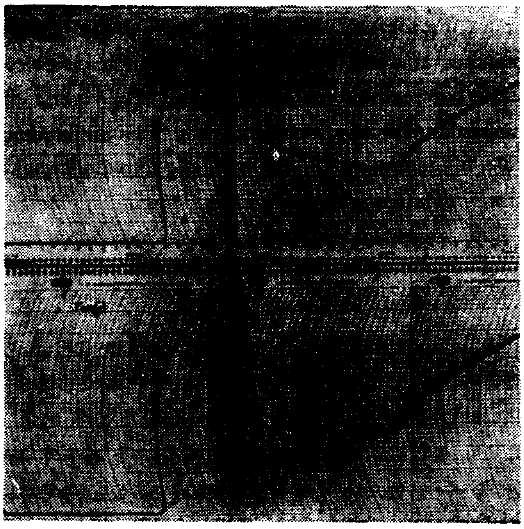

Fig. 1. An amylograph curve for Paldal (top) and Tongil(bottom) starch

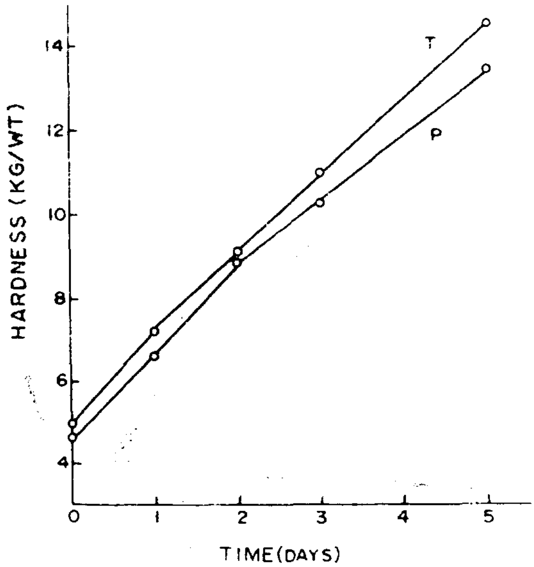

Fig. 2. Aging of Tongil(T) and Paldal(P) starch gels at 21°C

initial pasting temperature of 64°C, thereafter the viscosity increased sharply(Fig. 1). There were no significant differences in amylograph characteristics between the two starches, except Paldal starch had a somewhat higher peak height and Tongil starch showed a higher setback (height at 50°C)(Table 3).

The results of the hardness measurements on the aging of the starch gels at 21°C are shown in Fig. 2. The results of analyses of the Avrami equation on the aging of starch gels are given in Figs. 3 and 4. From Fig. 3, the Avrami exponent(n) for the Tongil and Paldal starch gels was found to be 1.01 and 1.02, respectively. The values for the rate constant (k) for Tongil and Paldal starch gels corresponded to 0.113 and 0.094 reciprocal days (Fig. 4), giving time constants(1/k) of 8.86 and 10.64 days (Table 4).

The value for the Avrami exponent(i.e., n=1) suggests that the mechanism of starch crystallization is instantaneous nucleation followed by rod-like growth of crystals.[17] The same mode of nucleation was reported for wheat,[14] cassava[18] and buckwheat.[19]

Some physicochemical properties of Tongil and Paldal starch are presented in Table 4. As noted from the value for the time constant, the rate of

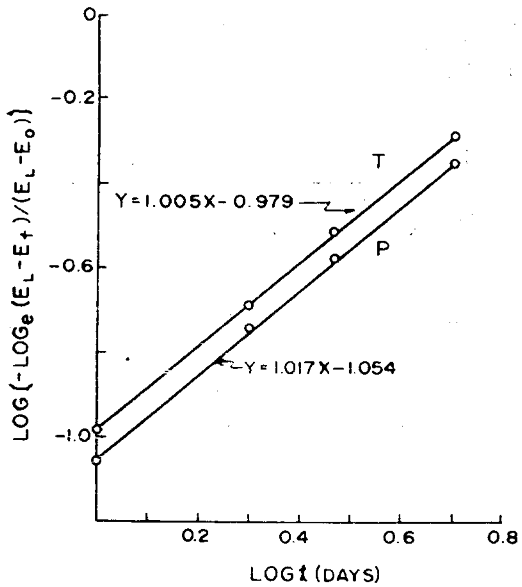

Fig. 3. Plot of log $[-\log_e(E_L-E_t)/(E_L-E_o)]$ against log t of 45% Tongil(T) and Paldal (P) starch gels at 21°C

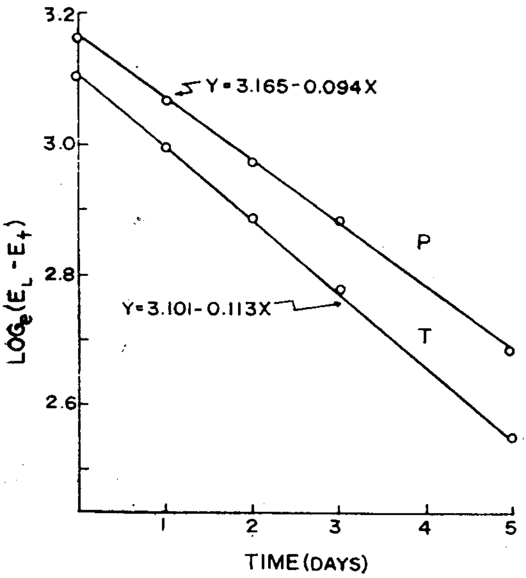

Fig. 4. Plot of $\log_e(E_L-E_t)$ against time of 45% Tongil(T) and Paldal(P) starch gels at 21°C

retrogradation of Tongil starch was faster than Paldal starch, which was also expected from the setback value (Table 3). It was suggested[18] that the linear amylose content is principally responsible for the rate of retrogradation of starch, that is, the higher the amylose content, the faster the rate of retrogradation. However, Kim *et al.*[19] postulated that for the starches having about the same amylose content the glucose units per segment for amylopectin may influence the rate of retrogradation of starch.

As shown in Table 4, no significant differences were found for amylose content and for the number of glucose units per segment for amylopectin between Tongil and Paldal starch. These results may imply that some other factor could passibly be involved in determining the rate of retrogradation of starch. The intrinsic viscosity for Tongil amylose was considerably higher than Paldal amylose, although the intrinsic viscosity for the amylopectin of both starches was about the same. These results thus imply that in starches in which the amylose content and the glucose units per segment for amylopectin are similar the molecular size of the amylose may play an important role in determining the rate of retrogradation of starch gels upon aging.

요 약

통일 및 팔달쌀 전분의 이화학적 성질을 살펴본 바, 전분의 물결합능력, blue value 및 아밀로스 함량에 서로 차이가 없었다. 팔달 전분은 통일 전분에 비해 팽화력이 높았다. 아밀로그라프에 의한 두 전분의 차이는 볼 수 없었으나 통일이 팔달보다 50°C로 냉각시 점도가 다소 높았다. 또한 통일 아밀로스의 intrinsic viscosity는 팔달 아밀로스보다 높았으나 아밀로펙틴은 두 전분모두 비슷한 값을 보였다. 전분 gel의 retrogradation 속도는 21°C에서 통일이 팔달보다 다소 빨랐다.

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