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Physicochemical and Gelatinization Properties of Starch and Flour from Pigmented Rice(Suwon 415)

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Abstracts

본 연구는 유색미 가루와 전분의 이화학적 특성 및 호화특성을 알아보기 위하여 수행되었다. 유색미 가루와 전분의 일반성분, 가루의 식이섬유 함량 및 보수력을 분석하였다. 주사전자현미경을 이용하여 가루와 전분의 형태를 관찰하였다. 유색미 전분의 청가 및 아밀로오스 함량을 측정하였고, 가루와 전분의 물결합 능력, 팽윤력과 용해도를 조사하였으며, RVA에 의하여 호화특성을 조사하였다.

유색미 가루의 일반성분은 수분 13.5%, 조단백질 9.1%, 조지방 2.2%, 회분 1.4%, 조섬유 1.3%이었고, 전분의 경우는 수분 13.6%, 조단백질 0.45%, 조지방 0.11%, 회분 0.12%이었다. 백미나 현미에 비하여 단백질의 함량이 매우 높았으며, 조지방과 회분, 조섬유의 함량은 백미에 비하여는 훨씬 높았고, 현미와는 비슷한 수준이었다.

유색미의 식이섬유 함량은 불용성 식이섬유가 3.3% 수용성 식이섬유 2.4%로 총 7.7%였다. 분리된 불용성 식이섬유의 보수력은 약 7.12(g H_2O/g NDF)로 매우 물과의 친화력이 큰 편이었다.

주사전자현미경에 의한 관찰결과 가루의 경우는 전분 주위에 단백질 등의 다른 성분들이 있는 것을 볼 수 있었으며, 전분은 다른 쌀전분과 마찬가지로 불규칙한 다각형의 형태였으며, 크기는 대부분 2~5㎛의 범위로 비교적 균일하였다.

유색미 전분의 청가는 전분이 0.11, 아밀로오스가 0.82, 아밀로펙틴이 0.07이었으며, 아밀로오스 함량은 16.8%이었다. 물결합 능력은 가루가 248%, 전분이 146%이었다. 팽화력과 용해도는 가루와 전분 모두 70℃ 이후 증가하였으며 전분이 가루보다 더 급격히 증가하였다.

RVA에 의한 호화양상에서 가루와 전분의 호화온도는 각각 85.7℃와 66.2℃로 나타났다. 최고점도는 가루가 127.7 RVU, 전분이 243.3 RVU로 차이가 컸으나, setback 후의 점도는 176 RVU과 187.7 RVU로 큰 차이가 없었다. 호화액의 consistency는 가루와 전분이 각각 92와 94로 비슷하였다.

Keywords : Pigmented rice starch, Pigmented rice flour, Physicochemical propeıty, Gelatinization property, Dietary fiber

I. Introduction

Rice (*Oryza sativa L.*) has been cultivated for centuries in many countries. Historical records indicate that rice cultivation began around 2000 and 1500 B.C. in an area extending from central India, through northern Burma, northern Thailand, Laos, Vietnam, and to southeastern China[1]. The cultivation of rice spread from the broad belt to Indonesia, the Philippines, and northern Australia. Later traders carried the grain throughout Asia, the Middle East, and Europe.

Rice is consumed primarily as cooked whole grains. The cooking of rice results in swelling and subsequent gelatinization of the starch in the rice endosperm, with absorption of water. Although rice starch may increase as much as 60 times in volume when cooked in water [2], the rice kernel swells no more than 4 times even in excess water, the non-starch constituents obviously suppressing this swelling[3].

It is generally believed that the amylose to amylopectin ratio is important determinant affecting the cooking and eating qualities of milled rice. Since these differences exist among varieties with similar amylose content, some additional indices are needed to differentiate among them, especially in breeding programs[4].

Pigmented rice, which was introduced into Korea, has been cultivated in China, Srilanka, Africa, and Philippines. It may be nutritionally superior to the

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white rice because it is unpolished like brown rice to maintain its color. Kennedy[5] reported that thiamin and oil contents of brown rice are approximately 5 times higher than those of the white rice, while fiber, niacin, phosphorous, potassium, iron, sodium, and riboflavin contents are approximately 2-3 times higher.

There are many rice varieties with diverse characteristics throughout the world and there is a distinct preference for rice based on race and region. Therefore, previous studies on rice have been mainly aimed at developing quick and good indices for predicting rice grain qualities in breeding programs in the countries where rice is consumed as a main staple [4].

Physicochemical properties of rice are becoming increasingly important in the industry. Appropriate basic information could make field research more productive. Researchers need to make their data more relevant to the needs of the industry[6].

Analysis of various physicochemical properties pigmented rice is concluded that fiber content and endosperm cell arrangement of pigmented rice flour, along with amylose content and gelatinization temperature, type of starch, are important factors that affect cooking qualities of pigmented rice. And from this data, it is expected that several studies of pigmented rice is connected with dietary fiber.

This study was carried out to investigate physicochemical and gelatinization properties of flour (PRF) and starch (PRS) of the pigmented rice (Suwon 415).

Materials & Methods

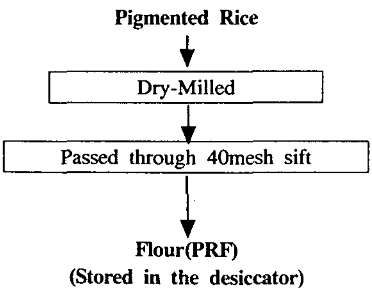


Fig. 1 Preparation of Pigmented Rice Flour.

Materials

Pigmented rice, Suwon 415 was given in Crops Experimental Station, Korea Rural Development Administration used in studies. Those were developed into standard samples at Crops Experimental Station, Korea Rural Development Administration. Pigmented rice was prepared dry-milled by using milling machine (SEDIMET, Brabender, Germany) and sifted through 40 mesh sieve. Obtained flour (PRF) was stored in the dessicator (Fig. 1).

For the preparation of starch pigmented rice was depigmented with 0.1% HCl-methanol. Starch sample (PRS) was prepared by alkali immersion method[7]. Details of procedure are described in Figure 2.

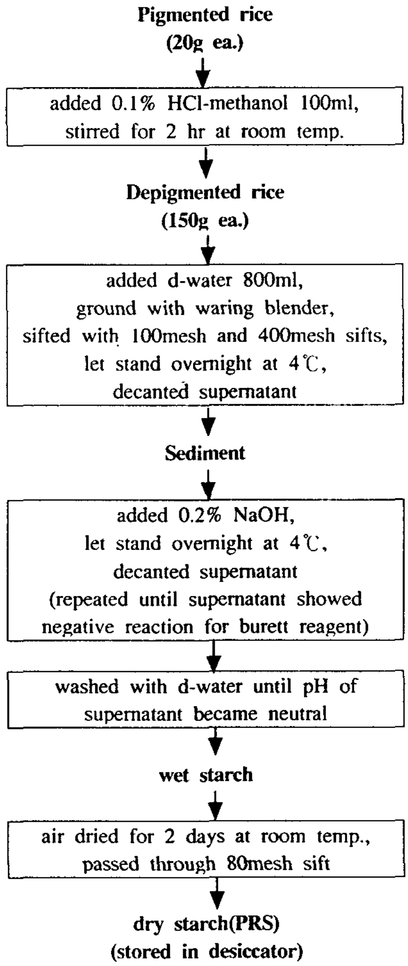


Fig. 2 Preparation of Pigmented Rice Starch.

Measurements of physicochemical properties

Proximate compositions such as moisture, protein, crude fat, and fiber of the pigmented rice flour and starch were measured according to the AOAC procedures[8].

Insoluble dietary fiber (IDF) and soluble dietary fiber (SDF) contents of the PRF were measured through the AACC procedures[9] and the water holding capacity (WHC) of the neutral detergent fiber (NDF)[9] through the method of Robertson and Eastwood[10].

The blue value (BV) of starch was measured using the method described by Gilbert and Spragg[11], and the amylose content through the method of Sowbhagya and Bhattacharya[12].

For measuring amylose content, amylose and amylopectin was separated from rice starch[13] and standard curve was obtained (Fig. 3).

Water holding capacities of PRF and PRS were measured by the method described by Medcalf and Gilles[14], and the swelling power and solubilities of PRF and PRS by the method described by Schoch[15].

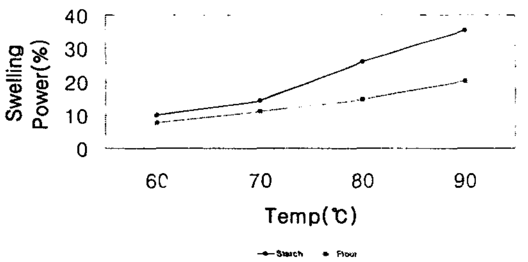


Fig. 4. Changes in swelling power of pigmented rice flour and starch by heating.

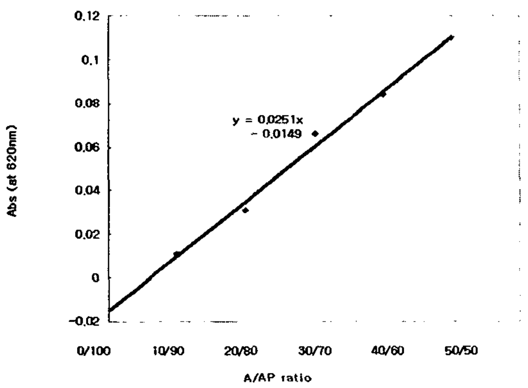


Fig. 3. Standard curve for amylose(A) and amylopectin(AP) isolated from pigmented rice starch.

Table 1. Operating condition of rapid visco analyser

Time(min)	Temperature Control
0 ~ 1	Heating from r. t. to 50℃
1.0 ~ 4.7	Heating from 50℃ to 95℃
4.7 ~ 7.2	Holding 95℃
7.2 ~ 11.0	Cooling from 95℃ to 50℃
11.0 ~ 13.0	Holding 50℃

Scanning electron microscopy

Shape of PRF and PRS was observed by SEM (Scanning Electron Microscopy ; S2500-C, Hitachi, Japan).

Gelatinization properties

The viscosity patterns of PRF and PRS suspension were determined using the rapid visco-analyzer (3D, Newport Scientific Pty., Ltd., Australia).

Three grams (as dry matter) of each sample was put into aluminum cup of rapid visco-analyzer and 25ml distilled water was added. Operating conditions were shown in Table 1.

Results & Discussion

Physicochemical properties

Proximate composition of the pigmented rice flour and starch are shown in Table 2. Moisture, crude protein, crude lipid and ash contents of PRF were 13.5%, 9.1%, 2.2%, and 1.4%, and those of PRS were 13.6%, 0.45%, 0.11%, and 0.12%, respectively.

Table 2. Proximate composition of pigmented rice flour and starch. (%)

	Moisture	Crude Protein	Crude Lipid	Ash	Crude Fiber
Pigmented rice					
Flour	13.5	9.1	2.2	1.4	1.3
Starch	13.6	0.45	0.1	0.1	-
Reference data					
Brown rice	11.0[a]	7.2[a]	2.5[a]	1.2[a]	1.3[a]
Rice	12.5[a]	6.3[a]	0.8[a]	0.4[a]	0.5[a]

a : National institute of health[16]

Table 3. Physicochemical Properties of Pigmented rice Flour and Starch.

	Flour	Starch
Dietary Fiber(%)		
Total	5.71±0.41	
Soluble	2.41±0.19	
Insoluble	3.29±0.38	
WHC(g H_2O/g NDF)	7.12±0.91	
Amylose Content(%)		16.8
Blue Value		0.11
Crystalline type		A-type
Water-binding Capacity	248	146

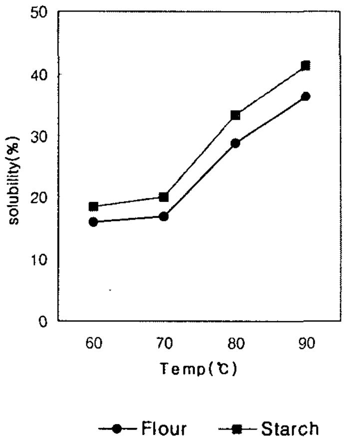


Fig. 5. Changes in solubilities of pigmented rice flour and starch by heating.

Pigmented rice seemed to have similar chemical composition as that of brown rice. However, crude protein content of pigmented rice was higher than that of brown rice. Protein content has been shown to vary according to the region and among crops grown in the same field[16]. The composition of PRS was similar to that starches from other rice species[17].

Other properties including blue value, amylose content, and water holding capacity of PRF and PRS are shown in Table 3. PRF contained relatively high dietary fiber (5.7%) which consists of 3.3% insoluble and 2.4% soluble fibers. Wang et al.[18] reported that pigmented rice in china showed the higher contents in total dietary fiber compared to brown rice. Similar result was reported by Ha et al.[19]. Water-holding capacity of the insoluble dietary fiber was 7.12g H_2O/g NDF.

Amylose content of PRS was 16.8%, According to the IRRI (International Rice Research Institute) classification[20]. Pigmented rice can be classified as intermediate-amylose. Amylose and insoluble amylose contents of rice affected stickiness, adhesiveness, storage hardness of cooked rice[21]. The blue value is usually used as an index of rice starch. PRS showed blue value of 0.11, crystalline type by X-ray diffractometry was A type.

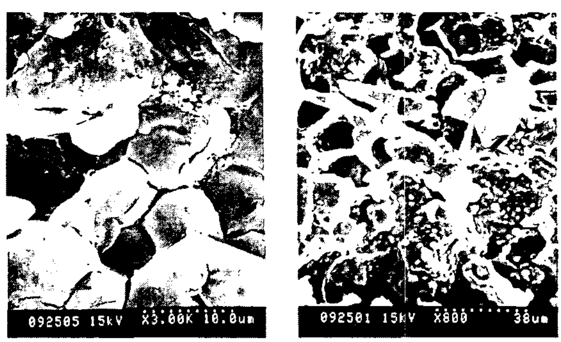
WBC of PRF and PRS were 248% and 146%, which were higher than those of other rice starches reported. Swelling power and solubilities of PRF and PRS increased abruptly from 70℃ with increasing temperature (Fig. 4, Fig. 5). Wong and Lelieve[22] reported that swelling power correlated with crystalization of starch granule. And above 75℃ increasing rate was lowered.

PRS exhibited a two-stage swelling and solubility pattern like as other cereal starches. Leach[23] explained this phenomenon by suggesting the presence of two different internal bonding forces in the highly organized and amorphous areas of the granule.

PRF showed lower solubility and swelling power than PRS, which it may becase of be swelling restraint of other components except starch of PRF[24].

Observation of shape

Scanning electron microphotographs of PRF(Fig. 6).



a b

Fig. 6. Scanning Electron Microphotoraphs of pigmented rice flour in different magnification ratio (a : 3000×, b : 800×).

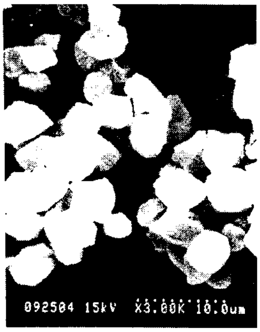


Fig. 7. Scanning Electron Microphotographs of pigmented rice starch at 3000×.

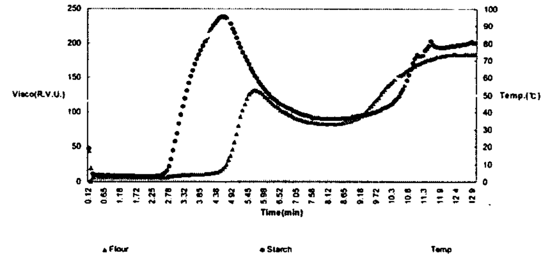


Fig. 8. RVA Viscogram of Pigmented rice flour and starch.

Table 4. Pasting characteristics of pigmented rice flour and starch by rapid viscoanalyzer.

	Temperature(℃)		Viscosity(RVU)					
	Initial increase	Peak	Peak (P)	Hold at 95℃ (H)	Cool to 50℃ (C)	Consistency (C-H)	Breakdown (P-H)	Setback (C-P)
Starch	66.2	91	234.3	93.7	187.7	94	130.6	-46.6
Flour	85.7	94.7	127.7	84	176	92	43.7	48.3

showed starch granules, and protein and other components surrounded them. Starch granules isolated were observed to have irregular polygonal shapes and sizes in the range of 2~5 ㎛ as shown in Figure 7.

In general, rice starch has the smallest granules among common starches ; diameter ranged from 2 to 10 ㎛ and starch granules vary in size from 2-100 ㎛ and may be round, oval, or irregular in shape. The granule shape and size depends on the apparent amylose content of the parent starch[25].

Gelatinization Properties

RVA curves of PRF and PRS are presented in Figure 8. Amylograph pasting characteristics of rice flour and starch are tabulated in Table 4. Initial gelatinization temperature of PRF and PRS by RVA were 66.2 and 85.7℃, respectively, and the peak viscosity of PRS were higher than that of PRF. There was little difference in consistency between them. Initial gelatinization temperature affected the amylose contents and the degrees of polymerization between molecules in the amorphous region. And the smaller starch granules were, the higher gelatinization temperature was observed[26]. Breakdown can be considered as indices fragility and solubility of swollen granules, whereas setback and consistency measure the tendency of association and retrogradation of elements in the hot paste during cooling[27]. Amylograph consistency of PRS and PRF were shown similar value, whereas breakdown of those was different. Breakdown and peak viscosity of PRF were larger than those of PRF. Low peak viscosity of PRF infer that amount of soluble starch as heating may be affect by other components of PRF.

Generally, amylograph curves shown by the reported rice varieties were typical of those of other cereal starches, But they showed appreciable differences among the varieties that are different in amylose. Size of peak viscosity, breakdown, setback, and consistency were determined primarily by the ratio of amylose and amylopectin and their correlation with amylose content will be discussed further[4]. Breakdown indicated the collapsable degrees of swollen starch and the resistance against heating in gelatinization[28] of PRF was higher than PRS.

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