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Physicochemical Properties of Mung Bean Starch Paste, a Main Ingredient of *Omija-eui*

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Abstract As a principle ingredient in *omija-eui,* the physicochemical properties of mung bean starch (MBS) paste were investigated and compared to those of rice and corn starch. The amylose and the protein content of MBS were higher than those of rice or corn starch while the total sugar content and the swelling power of MBS were lower. In addition, the clarity of MBS paste was higher than either rice or corn starch paste. Regarding pasting properties, the peak viscosity and cool paste viscosity of MBS were higher than those of either rice or corn starch. During the freeze-thaw cycle, MBS exhibited higher degree of syneresis than corn and rice starch, which decreased with high starch concentration and heating temperature. The paste properties and freeze-thaw stability of MBS showed a potential for improving the quality of *omija-eui*.

Keywords: *omija-eui*, mung bean starch, pasting property, freeze-thaw stability, syneresis

Introduction

Porridge, which is being consumed for a long time in Asia, is a dish prepared by boiling rice, maize, wheat, and other starchy cereals in water. It is usually an accompaniment to other dishes or is served to the ill, elderly, or infants, as it is easily consumed and digested (1). Even though it has been traditionally consumed at household level in Korea, its restaurant chains started recently to open and expand due to potential possibility as a valuable health food through the changes of ingredients and cooking processes (2).

Omija-eui is a transparent liquid food (porridge) traditionally made by boiling *omija* (berries of *Schizandra chinensis*) extract and adding mung bean starch (MBS), honey, or other ingredients (3). In Korea, *eui* means a boiled food, and it is similar to a watery fine porridge, using starch from adlay, sorghum, mung bean, arrowroot, and lotus root, among others (3). *Omija* vines are native to Korea, and over 22 species belong to the Schizandraceae family, and had 5 flavors (sour, sweet, bitter, salty, and hot flavors) that they are called five-flavor fruit in Korea. Because *omija* has a characteristic aroma and strong sour taste, it has been used in traditional medicine and more recently in various Korean food products (4,5).

MBS, which is a main ingredient of *omija-eui*, has high gel-forming ability and unique textures such as springiness and chewiness (6,7). In general, these characteristics resulted from thermal and mechano-chemical treatments of MBS, changing its rheological and functional properties (8). Kim and Shin (6) reported that the gelation and texture of MBS were affected by amylose levels, molecular weight, storage temperature, and water content. During storage after gelation, MBS is rapidly degraded and the gel structure is destroyed; clarity is also reduced by crystallization and dehydration (7).

When the starch paste is frozen and thawed during storage, the hydrogen bonds of water in the paste become unstable and less cohesive, and syneresis becomes apparent by dehydration of the paste and shrinkage of the amylose molecules (9,10). Lo and Rhamsden (11) reported that the phase change of water and the wave of heat energy induce destruction of the gel structure; thus, a paste structure with a high water content was more affected by syneresis during the freeze-thaw cycle.

The physicochemical properties of starch paste such as freeze-thaw stability and syneresis, which are closely related to retrogradation, are critical factors for controlling the quality of porridge. However, the freeze-thaw stability and the syneresis of MBS paste have not been investigated in detail as a main ingredient for the preparation of *omija-eui*. Therefore, in this study, the physicochemical properties of MBS paste were characterized and compared with those of rice and corn starch, which were commonly used for preparation of porridge.

Materials and Methods

Materials Mung bean (*Phaseolus aureus*), cultivated in Cheorwon province of Korea, was purchased from a local market. Corn starch was obtained from Daesang Co. (Seoul, Korea), and rice starch was purchased from Sigma-Aldrich (St. Louis, MO, USA). Starch was sieved through a 100 mesh (150-μm pore size) before use.

Preparation of mung bean starch (MBS) Starch was prepared from mung bean powder by the alkali method described by Cho and Kim (12) with some modifications. Briefly, the powder was suspended in 0.2%(v/v) NaOH, stirred for 1 min, and allowed to stand at 4°C for 24 hr. This process was repeated 5 times with the precipitate, and

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then distilled water was added until the pH 7±0.2 was reached. The starch was separated using a 100 mesh sieve and dried at 10°C. Starch yield was calculated as follows:

Extracted starch yield (%)=(Weight of mung bean starch/ Weight of mung bean powder)×100 (1)

Determination of composition The sugar, protein, and water content in mung bean, corn, and rice starch were measured by the AOAC (13) method. The amylose content was determined by the method of Hoover *et al.* (14) with some modifications. MBS (20 mg) was dissolved in 8 mL of 90% dimethylsulfoxide (DMSO) in 10-mL screw cap reaction vials. The contents of the vials were vigorously mixed for 2 min and then heated in a water bath (with intermittent shaking) at 85°C for 15 min. The vials were cooled to room temperature, and the contents were diluted with distilled water to 25 mL in a volumetric flask. A 1.0 mL aliquot of the diluted solution was mixed with distilled water (40 mL) and 5 mL of an I_2/KI solution (0.0025 M I_2 and 0.0065 M KI) and then adjusted to a final volume of 50 mL. The contents were allowed to stand for 15 min at room temperature. Amylose content was determined by measuring absorbance at 600 nm. All experiments were performed in triplicate.

Swelling power The swelling power (SP) was measured by the method of Li and Yeh (15). A starch sample (100 mg) was suspended in 10 mL of distilled water and held in a shaking water bath at 55, 65, 75, 85, and 95°C for 1 hr. The tubes were cooled rapidly to 20°C and centrifuged at 8,000×g for 20 min. The supernatant was carefully poured from the tubes. Only material adhering to the walls of the centrifuge tubes was weighed (Ws). The supernatant was dried to a constant weight (W_1) in an air oven at 100°C. The water soluble index (WSI) and swelling power (SP) were calculated as follows:

$$WSI=[W_1/0.1]\times 100\% \quad (2)$$

$$SP=Ws/[0.1(100\%-WSI)]\ (g/g) \quad (3)$$

Clarity The clarity was measured by the method of Bello-Pérez *et al.* (16). Starch pastes (1%) were produced by suspending a sample in 5 mL of water in screw cap tubes and placing them in a boiling water bath for 30 min. The tubes were thoroughly shaken every 5 min. After cooling to room temperature (15 min), transmittance (%T) at 650 nm was determined against a water blank.

Pasting properties The pasting properties of starches were evaluated using a rapid visco analyser (RVA-series 4V; Newport Scientic, Warriewood, Australia). Starch (3 g, 14% m.b.) and 25 mL of distilled water were mixed in an aluminum can using a paddle. The mixture was stirred for 1 min to facilitate dispersion before testing. Through a programmed heating/cooling cycle, the samples were held at 50°C for 1 min, heated to 95°C, held at 95°C for 2.5 min before being cooled to 50°C, and held at 50°C for 2 min. The heating and cooling rates were 12°C/min. Parameters recorded were pasting temperature (P_{temp}), peak viscosity (PV), hot paste viscosity (HPV; minimum viscosity at 95°C), cool paste viscosity (CPV; final viscosity at 50°C); breakdown (BD=PV−HPV), and set back (SB=CPV−HPV). All viscosity values were reported in rapid visco units (RVU).

Freeze-thaw stability Freeze-thaw stability was measured by the method of Sea-kang and Suphantharika (17) with some modifications. To compare with freeze-thaw stabilities of mung bean, rice, and corn starch pastes, the 25%(w/v) each starch solution was heated at 90°C for 15 min in a temperature-controlled water bath, followed by 24 hr storage at 4°C. In addition to analyze freeze-thaw stability of MBS with different pasting condition, the 35-55%(w/v) MBS solutions were heated at 45-60°C for 15-35 min in a temperature-controlled water bath, followed by 24 hr storage at 4°C. The sample pastes were subjected to a single freeze-thaw cycle of 20 hr storage in a −20°C freezer, followed by 4 hr storage at room temperature. The samples were then centrifuged at 4,000×g for 10 min. The free liquid was decanted, and the weight of the remaining gel was determined. The ratio of free liquid weight to the initial sample weight (expressed as a percentage) was used as a measure of syneresis.

Statistical analyses The results were expressed as mean ±standard deviation (SD) by analysis of variance (ANOVA) using Statistical Package for the Social Science (SPSS, Version 12.0, 2004; SPSS Inc., Chicago, IL, USA). Significant differences between sample means were determined at the $p<0.05$ level by Duncan's multiple comparison test. All experiments were performed in triplicate.

Results and Discussion

Composition of mung bean starch The yield of starch extracted from mung bean powder by the alkali method was 33.48%, which was higher than that for MBS (20.35%) recorded by Joo and Chun (18). The total sugar, protein, and water content of mung bean, rice, and corn starch were shown in Table 1. The total sugar content of MBS (98.93%) was lower than that of either rice (99.48%) or corn (99.55%) starch. MBS had the highest protein content at 0.17%; corn starch was lowest at 0.02%. Water content was in the order of rice>mung bean>corn starch. These results were similar to those reported by Choi and Oh (7) for MBS, i.e., 0.21% protein and 13.5% water content.

Physicochemical properties of mung bean starch The amylose content of MBS was 33.13%, compared to 27.49 and 16.63% for corn and rice starch, respectively (Table 1). This was similar to the 35.93% amylose content reported by Choi and Oh (7) and the 33.8% amylose content reported by Yoon and Kim (19). Kim and Shin (6) reported that the initial retrogradation rate of starch paste increased with amylose content, as an acceleration factor of pasting. Kwon *et al.* (9) reported that when starch paste was frozen and thawed during storage, the hydrogen bonds of water in the paste became unstable and lost cohesion, and thus syneresis was evident by gelation of the paste and shrinkage of amylose. Therefore, the retrogardation and the syneresis of MBS paste were expected to be rapidly enhanced by the high amylose content of MBS, which was mentioned in a later section of this study.

Table 1. Composition (%) of mung bean, rice, and corn starches

Starch	Total carbohydrate	Protein	Moisture	Amylose content
Mung bean	85.94±0.23$^{b1)}$	0.15±0.00^{a}	13.13±0.36^{ab}	33.13±0.22^{a}
Rice	87.79±0.38^{ab}	0.04±0.00^{b}	11.75±0.65^{b}	16.63±0.19^{b}
Corn	85.35±0.26^{a}	0.02±0.05^{c}	14.26±1.10^{a}	27.49±0.45^{c}

$^{1)}$All values are expressed as mean±SD of triplicate determination; $^{a\text{-}c)}$Values with different superscripts within the same column are significantly different among samples at α=0.05 level by Duncan's multiple range test.

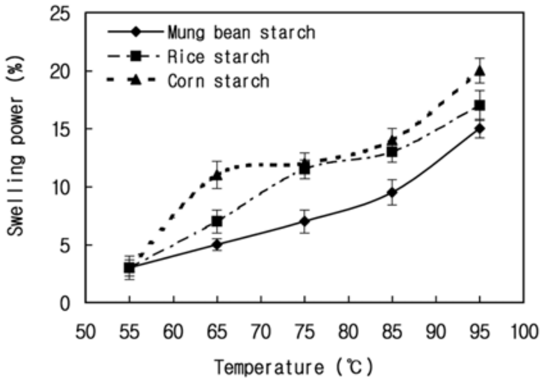

Fig. 1. The effect of temperature on swelling powers of mung bean, rice, and corn starches.

The change in swelling power with increasing temperature was shown in Fig. 1. The swelling power of MBS increased slowly compared to either rice or corn starch; however, the swelling power of MBS increased rapidly at 85°C. This result was similar to that reported by Li and Yeh (15), who found that swelling power increased as the heating process approached the peak temperature. We assumed that 85℃ was the critical temperature and, consequently, swelling power increased rapidly with degradation of starch granules at this temperature.

Table 2 showed the swelling power of corn, rice, and MBS which was 21.25, 16.90, and 15.56%, respectively. Tester and Morrison (20) reported that amylopectin was the most important factor affecting swelling power, and that the swelling of starch granules was inhibited by amylose. Thus, it is supposed that high amylose content and low swelling power of MBS prevent the interaction between water and MBS, increasing the syneresis of MBS paste.

The percentage transmittance (%T) of mung bean, corn, and rice starch was 17.80, 7.80, and 5.57%, respectively (Table 2). Hoover and Senanayake (21) reported that the clarity of starch increased with increasing amylose content. Therefore, we assumed that our result, i.e., that the clarity of MBS paste was higher than that of the other pastes, was due to the high amylose content of the MBS.

Table 2. Physicochemical properties of mung bean, rice, and corn starches (unit:%)

Starch	Clarity	Freeze-thaw syneresis
Mung bean	17.80±0.72$^{a1)}$	14.55±0.39^{a}
Rice	5.57±0.66^{c}	7.05±0.14^{c}
Corn	7.80±0.36^{b}	9.83±3.57^{b}

$^{1)}$All values are expressed as mean±SD of triplicate determination; $^{a\text{-}c)}$Values with different superscripts within the same column are significantly different among samples at α=0.05 level by Duncan's multiple range test.

Pasting properties The pasting properties of native MBS were investigated and presented in Table 3 and Fig. 2. Peak viscosities of the starch samples tested were in the range 1,488-2,750 RVU. The lowest peak viscosity was observed in rice while MBS exhibited the highest one. Hot paste viscosity ranged from 1,304-2,583 RVU and cold paste viscosity ranged from 2,059-4,878 RVU; it was the lowest for corn starch and the highest for MBS. The breakdown of starch followed the order of corn>rice> mung bean, while setback varied from 484 to 2,294 RVU and was the highest for MBS and lowest for corn starch. Chedid and Kokini (22) reported that the presence of the proteins decreased the peak viscosity of starch and that the amylose-amylopectin ratio, the type of protein, and temperature, coupled with residence time and moisture content, appeared to affect the extent of viscosity change. Olkku and Rha (23) reported that cold paste viscosity was largely determined by the retrogradation tendency of the leached amylose upon cooling. Breakdown was related to the shearing power of starch and its durability during heat treatment; thus, retrogradation was slower as the setback value decreased. Overall, the peak viscosity, hot paste viscosity, cool paste viscosity, and setback value were the highest for MBS, whereas the breakdown value was the lowest. The pasting temperature of MBS was the lowest at 78.13±0.04℃. Consequently, because the MBS paste

Table 3. Pasting properties of mung bean, rice, and corn starches

Starch	Peak viscosity (PV, RVU)	High paste viscosity (HPV, RVU)	Cool paste viscosity (CPV, RVU)	Breakdown (BD, RVU)	Setback (SB, RVU)	Peak time (min)	Pasting temp. (°C)
Mung bean	2,750±12.73$^{a1)}$	2,583.5±31.82^{a}	4,878±12.73^{a}	166.5±19.09^{b}	2,294.5±19.09^{a}	5.67±0.00^{b}	78.13±0.04^{b}
Rice	1,488.5±0.71^{c}	1,304±11.31^{c}	2,218.5±13.44^{b}	184.5±12.02^{b}	914.5±2.12^{b}	6.565±0.05^{a}	87.7±2.83^{a}
Corn	2,110.5±17.68^{b}	1,575.5±2.12^{b}	2,059.5±33.23^{c}	535±15.56^{a}	484±31.11^{c}	5.47±0.00^{c}	83.5±0.71^{a}

$^{1)}$All values are expressed as mean±SD of triplicate determination; $^{a\text{-}c)}$Values with different superscripts within the same column are significantly different among samples at α=0.05 level by Duncan's multiple range test.

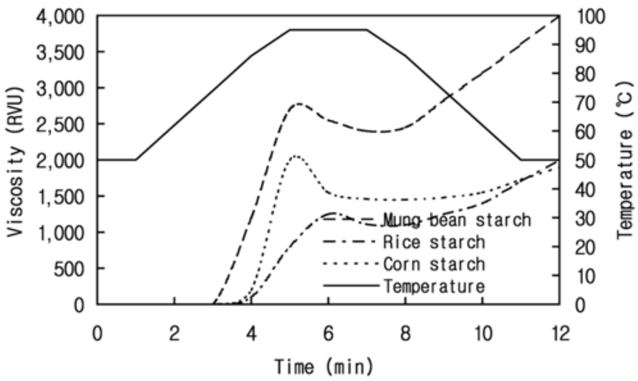

Fig. 2. Rapid visco analyser pasting properties of mung bean, rice, and corn starches.

increased the viscosity of the paste and decreased durability during heat treatment, it was assumed that the retrogradation of MBS was faster than the other starches, as suggested by the pasting properties.

Freeze-thaw stability of mung bean paste The syneresis of mung bean, corn, and rice starch were shown in Table 2. The syneresis for MBS (14.55%) demonstrated the lowest freeze-thaw stability compared to 7.05 and 9.83% for rice and corn starch, respectively. During freezing of the starch paste, the cohesive portion of the starch formed a layer and the rest separated into a water layer. The firm starch layer formed by freezing was assisted by the thick layer of the starch chain (24). Because the ice layer changed the volume of the water layer and was separated from the starch polymer layer, the starch gel displayed syneresis (24). Hoover (25) reported that the syneresis rate was decreased with an increase in amylopectin, high capacity of water, and inhibition of retrogradation. The results confirmed that the stability of MBS paste was reduced during the freeze-thaw process by a high amylose content, low swelling power, and low amylopectin.

The change of syneresis of MBS paste with different concentration, heating temperature, and heating time was shown in Fig. 3. The syneresis was decreased with increasing MBS concentration. Lee *et al.* (26) reported that starch granules aggregated during the freeze-thaw process and then syneresis occurred by phase separation. And Lo and Rhamsden (11) reported that the syneresis caused by the freeze-thaw process increased with high water content of the paste structure, inducing retrogradation. Therefore, we suggested that the freeze-thaw stability of MBS paste would be increased because the water content was decreased and the gel structure was more densified with an increase in MBS concentration. With different heating temperature, the syneresis was increased until 55°C, but the syneresis was rapidly decreased above 55°C. This result showed that the pasting of MBS was rapidly progressed above 55°C. When MBS solution was heated for 15, 20, 30, and 35 min, the syneresis of paste was not significant. Consequently, the syneresis of MBS paste in the freeze-thaw stability was affected by the starch concentration and heating temperature.

In conclusion, we investigated the physicochemical characteristics of MBS as a principle ingredient of *omija-eui*. Amylose and protein content of MBS were higher than those of rice and corn starch, but total sugar content and swelling power were lower. MBS also showed faster retrogradation rate than either corn or rice starch. Moreover, since the starch concentration and heating temperature in MBS paste preparation affected the syneresis, the conditions for the preparation of MBS paste seem to be a critical factor to control the quality of *omija-eui*.

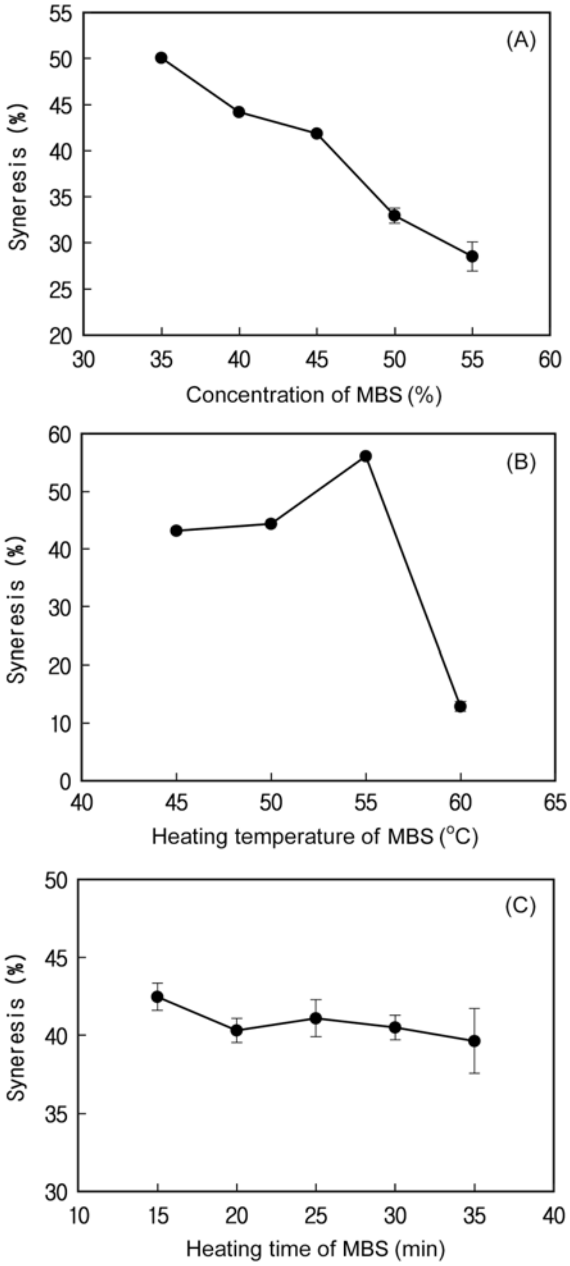

Fig. 3. Changes of syneresis of mung bean starch paste (MBS) at various concentrations (A), heating temperatures (B), and heating times (C).

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References

1. Cho HJ, Ahn CK, Yum CA. A study on the preference of *hobakjook* upon material and mixing ratio change. Korean J. Soc. Food Sci. 12: 146-152 (1996)
2. Ahn MS. The culture of Korean rice and porridge. Korean J. Food Culture 7: 195-202 (1992)
3. Lee HJ, Cho SH, Jeong RW, Cha KH. A *jook* on *jeonohjiryu* of *jeongjoji*. pp. 236-241. In: *Limwonsibyukji* (Korean Transitional Agricultural Encyclopedia). Seo YK (ed). Kyomunsa, Gyeonggi, Korea (2007)
4. Lyu HJ, Oh MS. Quality characteristics of *omija* jelly prepared with various starches. Korean J. Soc. Food Cook. Sci. 18: 534-542 (2002)
5. Zheng CH, Kim KH, Kim TH, Lee HJ. Analysis and characterization of aroma-active compounds of *Schizndra chinensis* (*omija*) leaves. J. Sci. Food Agr. 85: 161-166 (2005)
6. Kim JO, Shin MS. Retrogradation of rice flour gels with different storage temperature. Agric. Chem. Biotechnol. 39: 44-48 (1996)
7. Choi EJ, Oh MS. Changes in sensory and textural properties of mung bean starch gels during storage. Korean J. Soc. Food Sci. 15: 539-544 (1999)
8. Bhattacharya S, Sudha ML, Rahim A. Pasting characteristics of an extruded blended of potato and wheat flours. J. Food Eng. 40: 107-111 (1999)
9. Kwon JY, Song JY, Shin MS. Characteristics of non-waxy rice starch/gum mixture gels. Korean J. Food Cook. Sci. 21: 942-949 (2005)
10. Mariotti M, Sinelli N, Catenacci F, Pagani MA, Lucisano M. Retrogradation behavior of milled and brown rice pastes during ageing. J. Cereal Sci. 49: 171-177 (2009)
11. Lo CT, Ramsden L. Effects of xanthan and galactomannan on the freeze/thaw properties of starch gels. Nahrung 44: 211-214 (2000)
12. Cho SA, Kim SK. Particle size distribution, pasting pattern, and texture of gel of acorn, mung bean, and buckwheat starches. Korean J. Food Sci. Technol. 32: 1291-1297 (2000)
13. AOAC. Official Methods of Analysis. 16th ed. Method 925.04, 981.10, 954,02. Association of Official Analytical Chemists. Washington, DC, USA (1995)
14. Hoover R, Smith C, Zhou Y, Ratnayake RMWS. Physicochemical properties of Canadian oat starches. Carbohyd. Polym. 52: 253-261 (2003)
15. Li JY, Yeh AI. Relationships between thermal, rheological characteristics, and swelling power for various starches. J. Food Eng. 50: 141-148 (2001)
16. Bello-Pérez LA, Agama-Acevedo E, Sánchez-Hernández L, Paredes-López O. Isolation and partial characterization of banana starches. J. Agr. Food Chem. 47: 854-857 (1999)
17. Sae-kang V, Suphantharika M. Influence of pH and xanthan gum addition on freeze-thaw stability of tapioca starch pastes. Carbohyd. Polym. 65: 371-380 (2006)
18. Joo NM, Chun HJ. Effect of oil addition on texture of mung bean starch gel. Korean J. Soc. Food Sci. 7: 63-69 (1991)
19. Yoon JI, Kim SK. Effect of annealing on pasting properties and gel hardness of mung bean starch. Food Sci. Biotechnol. 12: 526-532 (2003)
20. Tester RF, Morrison WR. Swelling and gelatinization of cereal starches. I. Effects of amylopectin, amylose, and lipids. Cereal Chem. 67: 551-557 (1990)
21. Hoover R, Senanayake N. Composition and physicochemical properties of oat starches. Food Res. Int. 29: 15-26 (1996)
22. Chedid LL, Kokini JL. Influence of protein addition on rheological properties of amylose- and amylopectin-based starches in excess water. Cereal Chem. 69: 551-555 (1992)
23. Olkku J, Rha CK. Gelatinisation of starch and wheat flour starch-A review. Food Chem. 3: 293-317 (1978)
24. Ferrero C, Martin MN, Zantzky NE. Corn-srarch-xanthan gum interaction and its effect on the stability during storage of frozen gelatinized suspensions. Starch 46: 300-305 (1994)
25. Hoover R. Composition. molecular structure, and physicochemical properties of tuber and root starches: A review. Carbohyd. Polym. 45: 253-267 (2001)
26. Lee MH, Baek MH, Cha DS, Park HJ, Lim ST. Freeze-thaw stabilization of sweet potato starch gel by polysaccharide gums. Food Hydrocolloid 16: 345-352 (2002)