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Use of Gellan Gum and Xanthan Gum as Texture Modifiers for *Yackwa*, a Korean Traditional Fried Cake

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Abstract

Texture hardening of *Yackwa* during storage is the major quality deterioration of *Yackwa*. In this study the effects of gellan gum and xanthan gum on texture hardening of *Yackwa* during storage were studied. Instrumental hardness and sensory evaluation results showed that addition of 0.05% and 0.1% of gellan gum or 0.1% and 0.5% of xanthan gum significantly decreased the hardness of *Yackwa* by 32~63% after 4 weeks of storage. Retardation of texture hardening was obtained even at the 0.05% level of gellan gum, indicating that gellan gum was a more potent texture modifier for *Yackwa* than xanthan gum. Correlation analysis between moisture content and hardness of *Yackwa* showed that there was high correlation between moisture content and hardness of *Yackwa* after 4 weeks storage (r^2=-0.998), regardless of the initial moisture content. These results suggest that retardation of texture hardening during storage is primarily related to moisture retention of *Yackwa* during storage.

Key words: *Yackwa*, gellan gum, xanthan gum, textural hardening

INTRODUCTION

Yackwa is a Korean traditional fried cake made from wheat flour, honey and other ingredients such as sesame oil, ginger extract, etc. The typical process for making *Yackwa* includes mixing and kneading of ingredients, molding, deep fat frying and syrup-dipping processes (1). Recently, much interest has been focused on commercialization of *Yackwa* to satisfy consumer's needs for ethnic foods in Korea (2). *Yackwa* products have been manufactured in pilot plants and marketed on a limited scale, but some problems still exist for mass production and commercialization of *Yackwa*. Though it is a fried product having a high oil content, ranging from 11.5 to 28.7%, texture hardening and oil rancidity are the major quality deterioration, due to moisture loss during storage (3,4). The syrup-dipping process has been suggested to provide a kind of barrier to *Yackwa* that prevents the oil in *Yackwa* from coming into direct contact with oxygen in the atmosphere during long-term storage (1,4).

So far, research endeavors on *Yackwa* have been mainly focused on two categories. One is the effect of ingredients or process variables on quality attributes of *Yackwa*, and the other is the effect of ingredients and frying conditions on oil rancidity. These include the effects of rice or waxy rice (5,6) on the quality of *Yackwa*, the effects of process variables such as frying and syrup-dipping conditions on *Yackwa* quality (7,8), the effects of ingredients such as alcoholic drinks and emulsifiers on quality (9,10), and the effects of ginger extract on oil rancidity (4). Texture hardening due to moisture loss, however, has seldom been studied in an attempt to retard the texture hardening of *Yackwa* during storage.

Gums are polysaccharides, which compose of simple sugar-building units, having thickening, gelling and stabilizing effects (11,12). Because of these properties, gums are used in baked products to provide an uniform distribution of moisture throughout the batter, to improve the texture and the crumb structure, to enhance the mixing tolerance, and to prevent loss of volume and moisture during baking (13). Through the ability to bind water and to improve the texture of baked products, use of gums in *Yackwa* preparation might retard texture hardening during storage.

In this respect, we applied the gums as possible texture modifiers for *Yackwa*. Gellan gum and xanthan gum, having good water binding capacity and excellent stability to process variables (14-16), were selected for this study from preliminary screening. The objective of this study was to retard the texture hardening of *Yackwa* after storage by the use of gellan gum or xanthan gum as texture modifiers.

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MATERIALS AND METHODS

Materials

Wheat flour (Daehan Flour Mills, Korea), syrup (Dextrose equivalent 38~58, Daesang Co., Korea) and rice bran oil (Searim Co., Korea) were used as ingredients for *Yackwa* preparation. Gellan gum and xanthan gum were provided by CP Kelco (USA).

Yackwa preparation

For preparation of model *Yackwa*, wheat flour (62.9%), syrup (34.6%) and rice bran oil (2.5%) were mixed together and kneaded. Gellan gum and xanthan gum were added during the mixing and kneading process at the level of 0.05%, 0.1% and 0.1%, 0.5% (w/w) of total ingredients for dough preparation, respectively. The levels of gums were determined by a preliminary study. Prepared dough was molded and fried in rice bran oil at 170±5°C for 3 minutes. Fried *Yackwa* was dipped in syrup until syrup was fully penetrated into the center part of it. Dimensions of the final products, as measured with a Vernier caliper, were 6.42±0.21 cm in diameter and 1.12±0.21 cm in thickness (n=20). All the preparation processes were conducted on a plant scale using semi-automatic processes (Shinkung Traditional Food Co., Korea). To study the effects of gums on instrumental hardness, moisture content and sensory characteristics of *Yackwa* during storage, *Yackwa* samples were stored at 25°C for 4 weeks in a BOD incubator (Vision Scientific Co., Korea).

Physicochemical analysis

A rupture-test mode with a blade probe was used for analysis of the hardness of *Yackwa* using texture analyzer (TA.XT2, Stable Micro Systems, UK). The texture analyzer settings were as follows: pretest speed, 5 mm/s; test speed, 5 mm/s; posttest speed, 10 mm/s; strain, 70%. Surface color of *Yackwa* was determined using a portable spectrophotometer (Spectrophotometer, Color-eye, Minolta, Japan). Twenty samples prepared by each treatment were analyzed to investigate the effects of gums on texture hardening and surface color changes of *Yackwa* during storage. The moisture contents of *Yackwa* were analyzed by AOAC methods in triplicate (17).

Sensory evaluation

Sensory characteristics of fresh and 4 weeks-stored *Yackwa* at 25°C were evaluated using a fifteen-point scale (1=very low, 15=very high) for browning degree, sweetness, savory taste, hardness, stickiness and adhesiveness. These terms were derived by a from focus group interview. Prior to sensory evaluations, panelists chosen among students of Yongin University having experiences in sensory evaluations, were trained using fresh and stored *Yackwa* samples from three to four times a week for more than three weeks. A balanced incomplete block design was applied to evaluate the sensory characteristics of the entire treatment of fresh and 4 weeks-stored *Yackwa*, simultaneously. Each sample was tested 4 times by 5-trained panelists.

Statistical analysis

Two independent experiments were repeated to study the effects of gellan gum and xanthan gum on *Yackwa*. Similar results were obtained from two independent experiments and statistical significance of representative sets of experiments were analyzed using SAS software (18). GLM was used to determine the differences among treatments. When differences were found among treatments, Duncan's multiple range test was performed to test the level of significant differences among means.

RESULTS AND DISCUSSION

Effects of gums on texture hardening of *Yackwa*

The effects of gellan gum and xanthan gum on hardness changes of *Yackwa* were examined in terms of retardation of texture hardening during storage, which was the major quality deterioration factor of *Yackwa*. As shown in Fig. 1 (A, B), addition of gellan gum or xanthan gum affected the initial hardness of *Yackwa*. Hardness of *Yackwa* was significantly decreased by 58% with the addition of 0.1% gellan gum. Addition of xanthan gum also decreased the initial hardness of *Yackwa* by 27% and 42% at the level of 0.1% and 0.5%, respectively.

After 4 weeks of storage at 25°C, hardness of *Yackwa* increased upto 2.6 fold of the initial value, supporting the idea that textural hardening is the major quality deterioration of *Yackwa* (Fig. 1 C, D). Addition of gellan gum and xanthan gum also modified the hardness of 4 weeks-stored *Yackwa*. Gellan gum was a more potent texture modifier during long-term storage of *Yackwa* than xanthan gum. It significantly retarded the texture hardening of 4 weeks-stored *Yackwa* in a dose-dependent manner, i.e. hardness of 0.05% and 0.1% gellan gum-treated *Yackwa* were 68% and 37% of the control *Yackwa*, respectively. The lower hardness of xanthan gum-treated *Yackwa* suggested that application of xanthan gum also delayed the texture hardening of *Yackwa*. *Yackwa* treated with 0.1% xanthan gum exhibited a lower hardness than *Yackwa* containing 0.5% xanthan gum. But the large standard deviation in the 0.1% xanthan gum-treated *Yackwa* suggested that there were large intra-variances among the *Yackwa* samples. Though our samples were prepared in a pilot scale production facility equipped with semi-automatic processes, there were deviations in process variables such as frying temperatures judging from fry-

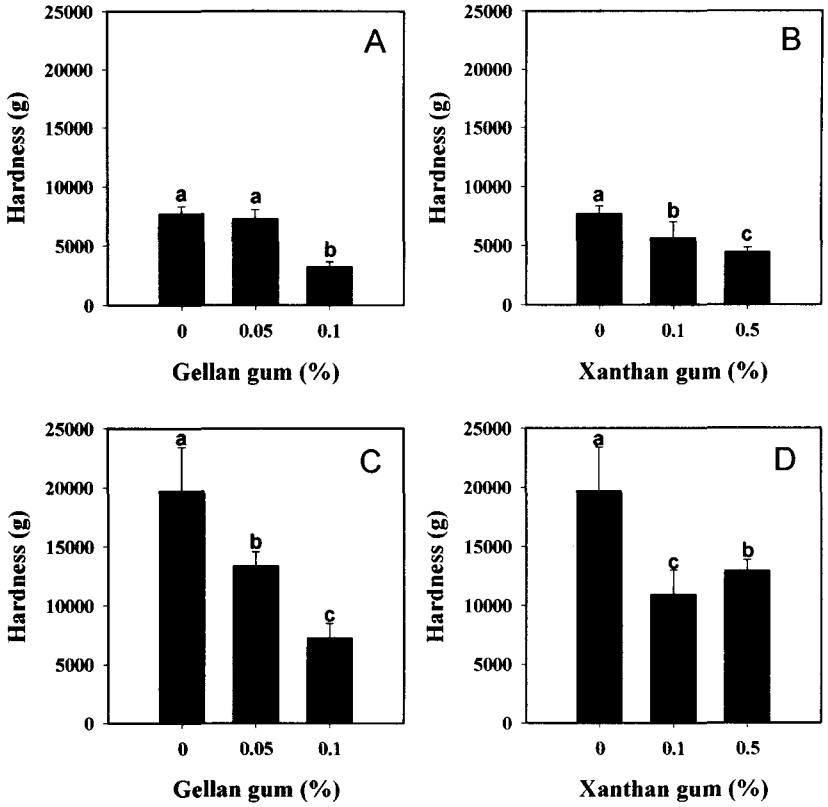

Fig. 1. Effects of gellan gum and xanthan gum on hardness of *Yackwa* during storage. *Yackwa* samples were stored at 25°C for 0 week (A, B) and 4 weeks (C, D). Gellan gum (A, C) and xanthan gum (B, D) were used at the indicated levels. Means with different letters are significantly different from one another ($p<0.05$).

ing temperature of 170±5°C. The observed lower hardness of *Yackwa* that was treated with 0.1% xanthan gum seemed to be related to the large intra-variances of *Yackwa* samples due to deviations in process variables. Further study will be needed to clarify this discrepancy.

Our results showed that use of gellan gum and xanthan gum as texture modifiers successfully retard the texture hardening of *Yackwa* during storage as well as decreasing the initial hardness.

Moisture content and hardness

To interpret the role of gums in retardation of texture hardening of *Yackwa* during storage, moisture contents of *Yackwa* were analyzed. Initial moisture contents of control and gellan gum or xanthan gum-treated *Yackwa* were ranged from 10.71% to 13.22% (Table 1). As shown in Fig. 1, initial hardness of *Yackwa* was lowered by addition of gellan gum or xanthan gum before storage. However, moisture content of *Yackwa* showed that the decreased initial hardness of *Yackwa* was not proportional to the initial moisture content. This result was supported by the low level of correlation coefficient, r^2= 0.413, which was obtained from the analysis of the correlation between initial hardness and moisture contents of *Yackwa* at time zero (Fig. 2). Gums have been used in bakery products as additives in order to improve texture as well as to increase moisture retention. Gums

Table 1. Effects of gellan gum and xanthan gum on moisture content of *Yackwa*[1)] during storage

Treatment		Moisture content (%)		Ratio[2)]
Gums	Concentration (%)	0 week	4 weeks	(4 weeks / 0 week)
Control	0	12.23±0.08[c3)]	9.05±0.03[d]	0.74
Gellan gum	0.05	13.22±0.09[a]	10.26±0.23[c]	0.78
	0.1	12.46±0.15[b]	11.75±0.29[a]	0.94
Xanthan gum	0.1	12.60±0.10[b]	10.89±0.24[b]	0.86
	0.5	10.71±0.03[d]	10.42±0.09[c]	0.97

[1)] *Yackwa* samples were stored at 25°C for 4 weeks.
[2)] Ratio = Moisture content of 4 weeks-stored *Yackwa* / Moisture content of 0 week-stored *Yackwa*.
[3)] Means with different letters within the same column are significantly different from one another ($p<0.05$).

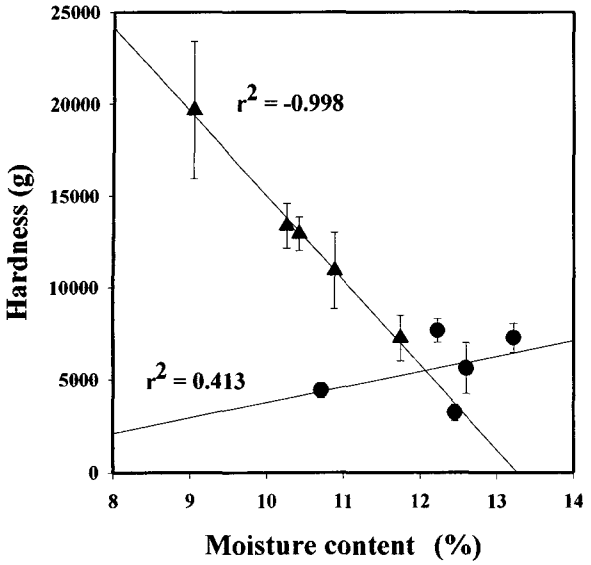

Fig. 2. Correlation between moisture content and hardness of gum-treated *Yackwa* during storage. *Yackwa* samples were stored for 0 week (closed circle) or 4 weeks (closed triangle) at 25°C.

have also been reported to induce structural changes in the major components of wheat flour system during breadmaking steps by possible interactions with starch or gluten and by modifying starch gelatinization (14,19). The decreased hardness of gums-treated *Yackwa* could be related to these possible actions of gums.

After 4 weeks storage, the moisture content of *Yackwa* were decreased due to water loss during storage, while moisture contents of gellan gum or xanthan gum-treated *Yackwa* were significantly higher than that of control. The ratio of moisture content of 4 weeks-stored *Yackwa* to that of 0 week-stored *Yackwa* showed obvious differences among control and gum-treated *Yackwa*. The moisture content ratios of *Yackwa* were increased upto 0.97 by the addition of gellan gum or xanthan gum, in a concentration-dependent manner, whereas the moisture content ratio of control was 0.74. These results demonstrate that moisture in *Yackwa* can be retained by gellan gum or xanthan gum treatment during storage. The higher moisture content was more highly correlated with lower hardness of gellan gum or xanthan gum-treated *Yackwa* than for control after 4 weeks storage at 25°C. As shown in Fig. 2, a high correlation coefficient between hardness and moisture content of 4 weeks-stored *Yackwa* was observed (r^2=-0.998).

These results indicate that retardation of texture hardening by the addition of gellan gum or xanthan gum might be related to moisture retention by gellan gum or xanthan gum. Concerning water holding capacity of gellan gum, Mao et al. (16) reported that gellan gum had very good water holding capacity, therefore the water content and texture properties of gellan gels did not change significantly after several months of storage when applied to a gelling system. Xanthan gum has also been reported to have good water retention properties, i.e. xanthan gum increased the moisture retention of dough for bread and tortilla preparation (14,15). These previous reports lend support to our results.

Surface color

As shown in Table 2, lightness of 0 week-stored *Yackwa* was decreased by xanthan gum and was increased by 0.05% gellan gum. Redness was decreased by gellan gum and yellowness was also decreased by both gellan gum and xanthan gum treatments. Lightness of 4 weeks-stored *Yackwa* was not affected by gum treatment except for 0.05% gellan gum-treated *Yackwa* of a lower level of lightness. Redness and yellowness of *Yackwa* were generally decreased by the addition of gellan gum and xanthan gum. Addition of gums decreased the redness and yellowness in both 0 week and 4 weeks-stored *Yackwas*. There have been few studies on exact role of gums in surface color of bakery products. In products

Table 2. Effects of gellan gum and xanthan gum on surface color of *Yackwa*[1)]

Storage time	Gums	Concentration (%)	Color difference			
			L	a	b	⊿E
0 week	Control	0	32.8±2.5[2)b3)]	4.3±1.2[a]	6.9±1.9[a]	26.4±2.8[bc]
	Gellan gum	0.05	34.9±2.6[a]	3.3±0.9[b]	4.9±1.9[b]	25.1±2.5[c]
		0.1	32.2±3.5[b]	3.1±0.7[b]	5.1±1.8[b]	27.6±3.4[ab]
	Xanthan gum	0.1	30.1±3.0[c]	3.6±1.3[ab]	6.9±1.6[ab]	28.4±2.5[a]
		0.5	30.1±3.2[c]	4.0±0.9[a]	5.5±2.0[b]	29.3±3.0[a]
4 weeks	Control	0	33.6±3.6[a]	5.1±1.7[a]	9.9±2.3[a]	25.1±3.8[b]
	Gellan gum	0.05	30.8±3.0[b]	4.2±1.3[b]	8.3±1.4[b]	28.2±2.8[a]
		0.1	34.3±2.5[a]	3.7±0.6[bc]	4.7±1.0[d]	25.5±2.4[b]
	Xanthan gum	0.1	32.5±3.5[ab]	3.2±0.8[c]	5.1±1.3[d]	27.3±3.3[ab]
		0.5	33.4±3.7[a]	5.3±1.9[a]	7.0±2.4[c]	25.7±3.9[b]

[1)] *Yackwa* samples were stored at 25°C for 4 weeks.
[2)] Mean±SD (n=20).
[3)] Means with different letters within the same column are significantly different from one another ($p<0.05$).

Table 3. Effects of gellan gum and xanthan gum on sensory characteristics of *Yackwa*[1)]

Storage time	Gums	Concentration (%)	Sensory characteristics					
			Browning degree	Sweetness	Savory taste	Hardness	Stickiness	Adhesiveness
0 week	Control	0	7.5±2.2[b2)]	12.3±2.4[ab]	10.1±2.6[b]	8.5±1.8[a]	6.4±1.8[ab]	7.3±1.3[c]
	Gellan gum	0.05	6.6±1.8[b]	12.5±1.6[ab]	11.0±1.4[ab]	9.1±2.0[a]	5.9±1.6[b]	10.9±1.4[a]
		0.1	10.1±1.6[a]	12.9±1.2[a]	12.3±1.5[a]	7.3±1.5[a]	8.5±1.8[ab]	9.4±2.0[ab]
	Xanthan gum	0.1	5.9±1.8[b]	10.9±1.2[b]	11.1±1.2[ab]	6.0±1.3[a]	6.9±1.5[ab]	7.7±1.9[bc]
		0.5	5.6±1.4[c]	13.1±0.6[a]	12.1±1.0[ab]	7.5±1.9[a]	9.5±1.9[a]	10.5±0.9[a]
4 weeks	Control	0	9.4±1.3[ab]	10.0±1.4[a]	9.0±1.0[a]	10.4±1.6[a]	4.1±1.8[c]	6.6±1.9[a]
	Gellan gum	0.05	8.3±1.1[b]	10.9±1.8[a]	8.6±1.7[a]	6.1±1.3[b]	5.4±1.3[bc]	8.4±1.3[a]
		0.1	10.8±1.3[a]	11.4±1.3[a]	9.6±1.8[a]	5.8±1.8[b]	7.9±1.5[a]	6.8±1.8[a]
	Xanthan gum	0.1	4.0±1.6[c]	12.1±1.7[a]	10.5±1.6[a]	6.6±1.3[b]	8.8±1.7[a]	8.9±1.7[a]
		0.5	3.9±1.6[c]	10.6±1.1[a]	10.7±1.7[a]	8.9±1.4[ab]	6.8±1.3[ab]	6.7±1.3[a]

[1)]*Yackwa* samples were stored at 25°C for 4 weeks.
[2)]Means with different letters within the same column of same storage time are significantly different from one another ($p<0.05$).

produced by deep fat frying, oil temperature and sample thickness were reported to be the most significant factors that affect the color parameters during frying (20). Though our *Yackwa* samples were produced in a plant-scale facility equipped with semi-automatic processes, frying temperatures of *Yackwa* processing were 170±5°C, indicating that there could be possible deviations in frying temperatures. The observed high standard deviations in the treatments suggested that there were intra-variances within each treatment group. The intra-variances in surface color of *Yackwa* could be due to deviations in frying temperatures due to mass production of *Yackwa*. Therefore, manufacturing high quality of *Yackwa* products may require the development of highly controlled automatic equipment for mass production of *Yackwa*.

Sensory evaluation

As shown in Table 3, browning degree of 0 week-stored *Yackwa* was increased by 0.1% gellan gum and was decreased by 0.5% xanthan gum. Sweetness of gellan gum- and xanthan gum-treated *Yackwas* was not significantly different from control. There were no significant changes in the savory flavor regardless of treatment, except for the addition of 0.1% gellan gum. Regarding texture attributes, gellan gum and xanthan gum addition did not cause significant changes in hardness or stickiness, but significantly increased the adhesiveness. These sensory attributes of 0 week-stored *Yackwa* imply that significant alterations in sensory characteristics of *Yackwa* were not observed except for the browning degree and adhesiveness by gellan gum or xanthan gum addition.

After 4-weeks storage, browning degree was not significantly changed by gellan gum addition, while treatment with xanthan gum significantly decreased the browning degree. In the case of hunter's color difference results, b values of 4 weeks-stored *Yackwa* were significantly decreased by gum treatment. However, there was little correlation between b values and browning degree of 4-weeks stored *Yackwa* (r^2=0.208). These results might be mainly due to intra-variances in surface color of *Yackwa* due to the frying process as mentioned above; further studies evaluating the effects of gums on color changes in bakery products are needed. Sweetness and savory flavor of gellan gum- and xanthan gum-treated *Yackwas* were not significantly different from control.

Both instrumental analysis and sensory evaluation of *Yackwa* revealed that addition of gellan gum and xanthan gum affected the hardness of *Yackwa* after storage. According to the sensory evaluation results, all the gum treatments significantly retarded the texture hardening of 4-weeks stored *Yackwa*, except 0.5% xanthan gum addition. Sensory evaluation results also showed that the effect of gellan gum was more pronounced in retardation of texture hardening during storage because gellan gum acted as a texture modifier at a lower level than xanthan gum. Concerning stickiness and adhesiveness, addition of both gellan gum and xanthan gum significantly increased the stickiness of *Yackwa*, while adhesiveness was not significantly affected by either gum treatment. Further study on the stickiness and adhesiveness changes and palatability of gellan gum and xanthan gum-treated *Yackwa* are needed.

These sensory evaluation results showed that the addition of gellan gum or xanthan gum successfully retarded texture hardening during storage without alteratering flavor characteristics of the final *Yackwa* products, whether fresh or stored for 4 weeks. From our instrumental and sensory evaluation results, it is expected that quality assurance for texture hardening of stored *Yackwa* can be obtained by application of both gellan gum and xanthan gum.

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