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Physicochemical Properties of Jeung-pyun (Fermented Rice Cake) as Influenced by Processing Conditions

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Abstract

Changes were evaluated in chemical and textural properties of Jeung-pyun (fermented rice cake) altered by the particle size of rice flour, amount of added Tak-ju (Korean traditional unrefined liquor) and sucrose, fermentation time and temperature, and steaming time. Particle size of polished rice flour did not affect the volume expansion during fermentation of rice dough by Tak-ju. The maximum expanded volume was noted in the dough, containing 20% sucrose (rice flour *vs* sucrose = 5 : 1, w/w), fermented at 35°C for 3 hours. Any volume expansion was not occurred in rice dough without sucrose. The highest value of reducing power and gelatinization degree were observed in the rice dough with Tak-ju (rice flour *vs* Tak-ju = 2 : 1, w/v), while the lowest blue value was revealed in that case. Steaming followed after fermentation made the smaller volume of bulk by 45~50% of the initial volume be showed just after fermentation. Jeung-pyun prepared under the conditions could give maximum expanded volume by fermentation showed the best overall quality by sensory and textual properties.

Key words : Jeung-pyun (fermented and steamed rice cake), expanded volume, reducing power, degree of gelatinization, textural property

INTRODUCTION

Rice cakes have long been known as traditional Korean favorite food used in feasts and folk festivals. It was recorded that more than 200 kinds of products were prepared in Chosun-Dynasty of Korea depending on rice species, garnitures and processing conditions. Korean rice cakes are differentiated from those made in neighbor countries such as Japan and China by rice species and processing methods used in cake manufacturing. Korean rice cakes are made of nonglutinous rice mainly[1] and its processing methods are divided broadly into four kinds : steaming (nonglutinous flour), steaming and pounding (glutinous rice grain), pan-frying, and boiling. Whereas Chinese and Japanese use glutinous rice and pounding method in rice cake manufacturing[2]. Among the various rice cakes, Jeung-pyun has been famous for its distinct processing method, taste and textural properties. Jeung-pyun is a fermented rice cake using Tak-ju (Korean traditional unrefined liquor) as enzyme source and it shows sour taste and softness like sponge cake, so it has been named as wine cake (Sul-tok), snow cake (Sul-byung) or steamed cake (Jeung-byung)[3]. In some primitive forms of the process, Jeung-pyun was prepared with steamed rice dough which had been fermented using Tak-ju as enzyme source. Despite of its unique taste and texture, demand for Jeung-pyun has been limited in home and industrial manufacturing because of its uncertain processing conditions and instability during storage. There have been two attempts to modernize and improve

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this process that involved substituting dry yeast as enzyme source for Tak-ju[3], and effect of added wheat flour and fermentation time on Jeung-pyun quality[4]. But the general recipe for home made Jeung-pyun is still recommended using rice flour with Tak-ju and sucrose[5,6]. Literature is sparse on the effect of processing conditions on Jeung-pyun quality and standardized method for processing. Therefore, this study was undertaken to : (1) ascertain the effects of mixing ratios of ingredients and processing conditions on physicochemical properties of Jeung-pyun, (2) standardize the method for preparation of home made Jeung-pyun using Tak-ju, (3) evaluate the Jeung-pyun with respect to texture and overall quality by sensory evaluation.

MATERIALS AND METHODS

Samples

The nonglutinous rice samples (90% polished of medium grain varieties (Dong-jin) from 1988 harvest were obtained from the local Agricultural Cooperative Association (Haeundae Pusan, Korea). Tak-ju, containing 6.5% of ethyl alcohol, was purchased from Jang-Soo Food Co. (Pusan, Korea) in June 1989 and stored at 0~4℃ prior to use. Table 1 shows the proximate composition and amylose content of ingredients for Jeung-pyun. The maltose content and activity of α-amylase of Tak-ju are listed also.

Preparation of Jeung-pyun

Rice flour was made by soaking 800 grams of rice in 1.6 liter of tap water for 3 hours and then draining water. Drained rice was ground in a Willey mill to pass 20~80 mesh screens. Prior to preparing the rice dough, Tak-ju was mixed with sucrose and warmed it in water bath at 30℃ for 10 minutes and that mixture was used as α-amylase source. The recipe of rice dough for Jeung-pyun is as follow ; wet rice flour (90 gram), Tak-ju (23~54 ml), sucrose (0~36 gram). The ingredients were mixed with each other for 5 minutes using Hobart mixer. Prepared dough was fermented at 25~45℃ for 0~4 hours and then steamed for 10~20 minutes. After steaming, products were allowed to cool to room temperature and sealed in polyethylene film bag. Sealed Jeung-pyun was stored at 4℃ and subjected to physical and chemical analyses.

Chemical analyses

Amylose content in rice products was determined by the method of total-amylose[7]. *In vitro* starch digestibility was expressed as reducing power. The amounts of reducing saccharides released by the treatment with α-amylase solution (8mg porcine pancrease, 15 units/mg solid, Sigma) were determined spectrophotometrically with 3,5-dinitrosalicylic acid (1% in 0.4 N NaOH containing 30% sodium potassium tartrate) according to the method of Bruner[8]. Maltose (hydrated form, m.w. 342.3, Sigma) was used as calibration standard. Blue values of the hydrolyzates were determined using the method of Gilbert and Spragg[9]. A method of Whelan[10] was used for determining α-amylase activity from calibration curve of maltose (Fig. 1). Activity was defined as the amount of enzyme required to release maltose (mg/ml) from 1% soluble potato starch solution. The content of maltose and amylase activity in Tak-ju was determined by subs-

Table 1. Proximate composition and amylose content of ingredients for Jeung-pyun[a]

% wet basis (% moisture free basis)

Sample	Moisture	Crude protein	Total lipid	Ash	Amylose	Maltose	α -amylase[b] activity
Rice	11.3	5.82 (6.56)	1.10 (1.24)	0.52 (0.59)	–	–	–
Rice flour	39.8	5.80 (9.63)	1.00 (1.66)	0.20 (0.34)	13.24 (22.00)	–	–
Tak-ju	90.7	1.90 (20.40)	0.10 (1.08)	0.10 (1.08)	–	0.14	1.6
Jeung-pyun[c]	50.56	3.01 (6.09)	0.35 (0.71)	0.12 (0.24)	10.14 (20.50)	–	–

The data are averages of three determinations. Values are listed as mean.

[a] Fermented and steamed rice cake, [b] amylase unit/ml of Tak-ju,

[c] Ingredients ratio ; rice flour : sucrose : Tak-ju=10 : 2 : 5 (w/w/v).

Fermenting time and temperature ; 3 hours and 35℃, Steaming time ; 15 minutes

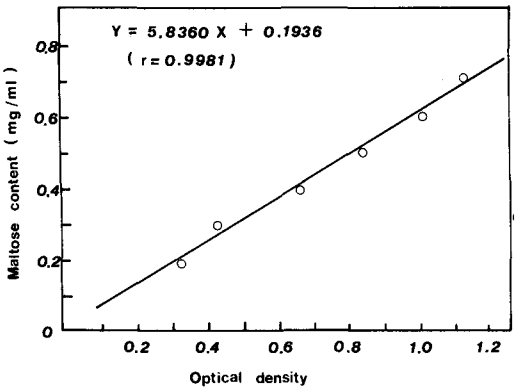

Fig. 1. Calibration curve of maltose concentration to optical density at 540 nm for determination of α-amylase activity.

tituting Tak-ju for amylase solution and soluble starch solution under the above conditions. The procedure introduced in "Methods of Food Analysis, in Japanese"[11] was adopted for determining the degree of gelatinization on fermented and/or steamed rice dough.

Volume expansion

The doughs were placed in a graduated cylinder with 8cm of diameter and covered with cheese cloth. Initial dough volume was noted, and then the cylinders were incubated and steamed. After incubation and steaming, the final volume was observed and calculated as the percentage increase in volume. All represented data were the mean of triplicates.

Sensory evaluation

A group of 11 Korean whose ages ranged from 18 to 40 years were asked to evaluate the organoleptic properties including grain, softness, sourness, chewiness and overall quality of the products. Samples were coded using three digit letters and were evaluated in random order. Evaluations were carried out using a 7 point of Multiple Comparison Difference Analysis[12] where 7 is equivalent to "excellent" and 1 is "very poor". Scores were analyzed using the mean of the observations and analysis of variance. Test of significance were at 0.05 levels of probability using Duncan' s multiple range test[13].

Test of texture

The texture of products, such as hardness, adhesiveness, springiness, chewiness and gumminess, were done on a $1.5 \times 1.5 \times 1.5 cm^3$ size of Jeung-pyun. Evaluations were accomplished by using a Universal Testing Machine (Instron Model 1140). A generalized texture profile analysis curve from testing machine is illustrated in Fig. 2.

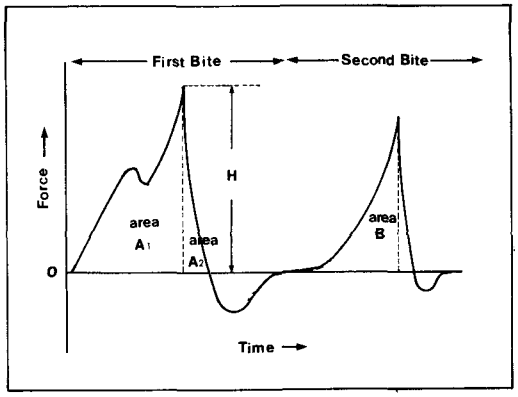

Fig. 2. A generalized texture profile analysis curve from the Instron Universial Testing Machine.

Hardness : H, Adhesiveness : area B/(area A1 + area A2)
Springiness : area A1/(area A1 + area A2)
Chewiness : H × adhesiveness × springiness
Gumminess : H × adhesiveness

RESULTS AND DISCUSSION

Effect of processing conditions and ingredients ratios on volume expansion

The data on changes in volume of rice dough prepared with various rice flour, particle sizes were ranged from 20 to 80 meshes, are presented in Table 2. As shown in Table 2, particle sizes of rice flour did not affect the volume expansion because polished rice have a lesser content of fiber that hinders hydrolysis by amylase[14]. Therefore, particle size of rice flour used in following experiments is 60 meshes because that was the major portion of products from first operation of Willey mill. Fig. 3 (A, B, C and D) shows the results of expanded volume of both raw and steamed dough (Jeung-pyun) in different conditions and ingredients ratios. The largest volume was obtained for dough fermented at 35℃ (Fig. 3A) and the other

Table 2. Effect of particle sizes on volume expansion of rice dough* for Jeung-pyun after fermentation**

Particle size (mesh)	20	40	60	80
Volume (cc)	315±12	318±6	325±10	330±12

* Initial volume : 185 cc

**Ingredients : rice flour (90 gram), sucrose (18 gram), Tak-ju (32ml), water (13ml)
Fermenting time : 3 hours, Fermenting temperature : 35℃

temperatures were not successful in volume expansion. These observation suggested that the optimum temperature of enzymes in Tak-ju involving rice starch fermentation was around 35℃. This fermentation temperature was consistent with the temperature including sour taste and unique taste of Jeung-pyun[3]. On the other hand, volume expansion of dough was depend on the sucrose : rice flour ratio during fermentation. For example, a sucrose : rice flour of 2 : 10 or 3 : 10 (w/w) were found to give a greater volume expansion during fermentation with Tak-ju at 35℃ for 3 hours, while dough without sucrose did not showed any volume expansion (Fig. 3B). These results suggested added sucrose served as a enzyme starter and sweetners in preparation of Jeung-pyun. Levels of added Tak-ju affected in volume expansion of both raw and steamed dough (Fig. 3C). A volume of dough was increased until the amount of added Tak-ju reached 50% of rice flour (v/w) but 60% had a lesser effect on expansion than that level. Despite of the increased volume of dough, it was reduced to 40~50% of initial expanded volume after steaming. From the results above, Jeung-pyun prepared from the dough prepared with rice flour and Tak-ju (10 : 5, v/w) could served the original its taste (sourness) and flavour. The time course of fermentation for volume expansion of both raw and steamed dough was presented in Fig. 3D. The 3 hours fermented dough had a greater volume ex-pansion than the other samples. Over 3 hours fer-mentation resulted a smaller volume and partial removal of original flavour of Jeung-pyun due to the elimination of bubbles and shrinkage[3].

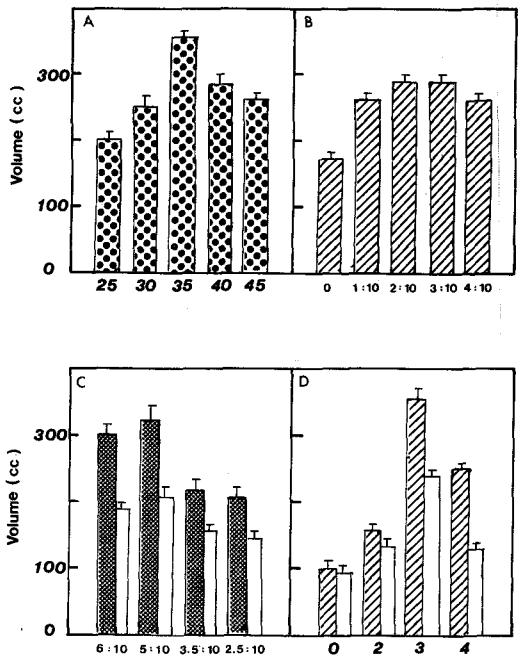

Fig. 3. Effect of processing conditions on volume expansion of rice dough for Jeung-pyun.
*A : Rice flour (w) : Tak-ju (v) : Sucrose (w) = 10 : 5 : 2, Fermenting time ; 3 hours
B : Rice flour : Tak-ju = 2 : 1 (w/v), fermenting temperature and time ; 35°C, 3 hours
C : Rice flour : Sucrose = 5 : 1 (w/w), fermented at 35°C for 3 hours
■ ; volume before steaming
□ ; volume after steaming
D : Rice flour (w) : Tak-ju (v) : Sucrose (w) = 10 : 5 : 2, fermenting temperature ; 35°C
▨ ; volume before steaming
□ ; volume after steaming

Digestibility of Jeung-pyun

Effect of the amount of added Tak-ju

Changes in digestibility of Jeung-pyun prepared under various mixing ratio of Tak-ju and rice flour, as measured by blue value, reducing power and degree of gelatinization, are shown in Fig. 4. In the range of 2.5 : 10 (Tak-ju : rice flour, v/w) to 5 : 10, reducing power and degree of gelatinization were increased slightly with the amount of added Tak-ju increased in that range. These results indicate that hydrolysis with enzymes in Tak-ju (mainly α-amylase showed "multiple attack" mechanism[16], i.e. the hydrolysis an α- 1, 4-linkage by randomly, and then increases the starch digestibility by the liberated small oligomers, mainly maltose and maltotriose. In the case of amylopectin, not only are br-

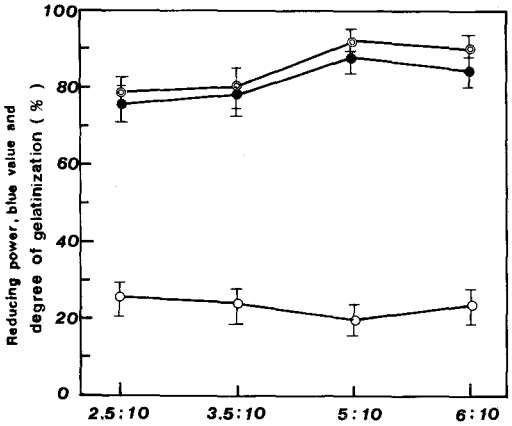

Fig. 4. Changes in reducing power (●), blue value(○) and degree of gelatinization (◎) of Jeung-pyun as a function of added amount of Tak-ju to rice flour.
*Rice flour : Sucrose = 5 : 1 (w/w)
Fermenting temperature and time ; 35°C, 3 hours

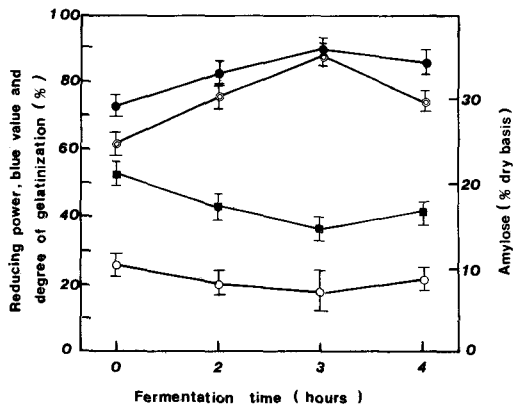

Fig. 5. Comparisons of reducing power (●), blue value (○), degree of gelatinization (◎) and amylose content (■) from rice dough for Jeung-pyun during fermentation.
*Rice flour (w) : Tak-ju (v) : Sucrose (w) = 10 : 5 : 2. Fermenting temperature : 35°C

anch points themselves resistant to hydrolysis by α-amylases but also they confer some degree of resistance to neighboring α-1, 4-linkages. Unlike reducing power, blue value mainly indicated the effect of random attack, as the blue value depends on chain length and attacks by enzyme greatly affect chain length. Thus, raw rice starch was hydrolyzed slowly by the enzymes in Tak-ju during fermentation of Jeung-pyun. On the other hand, the degree of gelatinization was increased with the amount of added Tak-ju increased to 50% level of rice flour (v/w).

As evident from Fig. 4, the structure of raw rice starch was changed to be susceptible to enzyme reaction through gelatinization.

Effect of fermentation and steaming time

From the fermentation curves shown in Fig. 5, it can be seen that the hydrolysis pattern, on the basis of estimation of reducing power, blue value and degree of gelatinization, was similar to that in samples contained various amount of Tak-ju as in Fig. 4. Under the conditions applied, the reducing power increased slowly with fermentation time increased up to 3 hours but there were a slight decrease in blue value after that time. These may be contributed to a lower iodine-amylose complex

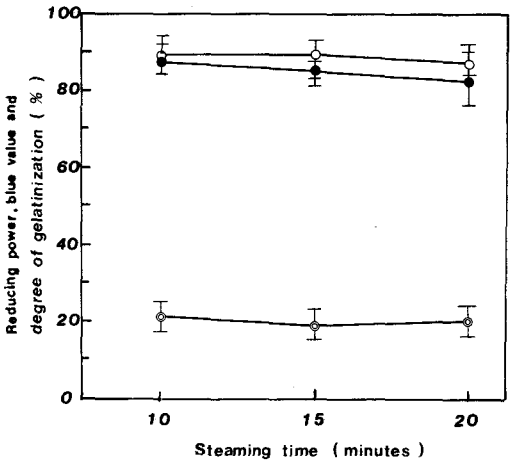

Fig. 6. Changes in reducing power (○), blue value (◎) and degree of gelatinization (●) of rice dough for Jeung-pyun after steaming. Conditions of preparation is same as in Fig. 5.

from shortened amylose chain by enzyme[16]. Unlike reducing power, degree of gelatinization of samples fermented for 3 hours was considerably higher compared to other ones. This apparent increase in gelatinization degree may be attributed to starch fragmentation and opening up of the structure by enzyme in Tak-ju during fermentation. It is known that numerous hydroxyl side groups in amylose allow the close alignment that permits hydrogen bonding between molecules. This bonding results

in aggregate formation with hydration and decreased solubility in aquous solvents[17]. Therefore, amylose content is frequently used to evaluate the digestibility of starch[18] since aggregation of amylose may prevent the exposure of many potential sites for amylase activity and hence cause a general reduction in hydrolysis. In Fig. 5, it is compared the amylose content in rice dough that occurs after various fermentation period ranged from 0 to 4 hours. There was a lowering in amylose content at 3 hours after fermentation. These results may be consistent with findings of blue value, reducing power and gelatinization of rice starch during fermentation of Jeung-pyun. Fig. 6 shows the changes in digestibility after steaming of fermented rice dough. There was a substantial increase in gelatinization and blue value at 10 and 15 minutes after steaming. But the increment of both values were negligible compared to the changes occurred in raw rice starch during fermentation.

Sensory evaluation of Jeung-pyun

Table 3 compares the results of sensory evaluation for Jeung-pyun prepared with various amounts of Tak-ju added and fermentation periods. Statistical analysis shows that there was a significant difference in "grain" and "overall quality" ($p<0.05$) and JAT-50 (rice flour : Tak-ju = 10 : 5, w/v) revealed the highest mean scores of those indices. On the other hand, the highest score of "softness" was noted in both JAT-50 and JAT-60 (rice flour : Tak-ju = 10 : 6, w/v) but those scores were not a greater compared to other' s. These results suggested that "softness" of Jeung-pyun was not significantly affected by the amount of Tak-ju added. In case of "sourness", it was noted same scores in all samples except JAT-60 which showed the lowest score among samples. From the results above, it is confirmed the amount of Tak-ju added could not affect on sourness of Jeung-pyun greatly. Aside from JAT-50, there was not a significant difference in chewiness between samples also. Unlike the effect of amount of Tak-ju added, fermentation period had a great influence on sensory quality. Jeung-pyun from the dough fermented for 3 hours (J-3), under the optimum conditions described in Fig. 3 to 6, was most acceptable in terms "grain", "sourness", "chewi-ness" and "overall quality" ($p<0.05$).

Textural properties of Jeung-pyun

Table 4 shows that textural properties of Jeung-pyun influenced by preparation conditions including mixing ratio of Tak-ju with rice flour and fermentation period. Hardness, adhesiveness, chewiness and springiness were found to be lower in sample JAT-50 than the other samples subjected and

Table 3. Scores[a] of sensory evaluation for Jeung-pyun

Sample[b]	Grain	Softness	Sourness	Chewiness	Overall quality
JAT-60	4.5^{a}	4.9^{a}	4.3^{b}	4.7^{a}	5.0^{a}
JAT-50	6.6^{ac}	4.9^{a}	5.7^{a}	3.2^{ab}	5.5^{a}
JAT-35	5.0^{ac}	4.5^{a}	5.7^{a}	4.9^{a}	5.3^{a}
JAT-25	3.1^{bc}	4.3^{a}	5.7^{a}	3.8^{a}	3.4^{b}
J-0	3.4^{b}	1.9^{b}	4.0^{bc}	6.1^{a}	1.3^{b}
J-2	4.0^{b}	4.0^{a}	5.0^{ac}	4.5^{b}	3.9^{a}
J-3	6.4^{a}	4.9^{a}	5.7^{a}	3.2^{bc}	5.3^{a}
J-4	4.0^{b}	4.2^{a}	6.3^{a}	4.9^{ab}	4.0^{a}

[a] Means with same letters are not significantly different at $p<0.05$

[b] JAT-60 ; rice flour : sucrose : Tak-ju=10 : 2 : 6 (w/w/v), fermenting time (3 hours), fermenting temperarture (35℃), steaming time (15 minutes)

JAT-50 ; rice flour : sucrose : Tak-ju = 10 : 2 : 5 (w/w/v), the other conditions are same as in case of JAT-60

JAT-35 ; rice flour : sucrose : Tak-ju = 10 : 2 : 3.5 (w/w/v), the other conditions are same as in case of JAT-60

JAT-25 ; rice flour : sucrose : Tak-ju = 10 : 2 : 2.5 (w/w/v), the other conditions are same as in case of JAT-60

J-0 ; Ingredients ratios, steaming time and temperature are same as in case of JAT-50 but fermenting time is 0 hour

J-2 ; Fermenting time is 2 hours and the other conditions are same as J-0

J-3 ; Fermenting time is 3 hours and the other conditions are same as J-0

J-4 ; Fermenting time is 4 hours and the other conditions are same as J-0

Table 4. Textural properties[a] of various Jeung-pyun products using Instron Universal Testing Machine

Sample[b]	Hard-ness	Adhesi-veness	Springi-ness	Chewi-ness	Gummi-ness
JAT-60	6.70	0.50	0.18	2.71	3.35
JAT-50	5.10	0.38	0.65	1.25	1.94
JAT-35	6.20	0.39	0.85	2.05	2.42
JAT-25	6.28	0.40	0.80	2.00	2.51
J-0	8.70	0.50	0.84	3.65	4.35
J-2	6.50	0.44	0.89	2.54	2.86
J-3	5.20	0.37	0.66	1.27	1.92
J-4	5.40	0.39	0.81	1.71	2.10

[a] See the abbreviations in Table 3

these results were in agreement with the results from sensory evaluation. JAT-50 had the second lowest gumminess, but not significantly lower than JAT-35 or JAT-25. A general downward trend in all of properties, shown in Table 4, was observed with prolonged fermentation period to 3 hours. Therefore, sample JAT-50 (J-3) was most acceptable in terms of sensory qualities and textu-ral properties.

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제조 조건에 따른 증편의 품질

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요 약

우리나라의 떡 중에서 맛, 질감 및 제조 방법이 독특한 것으로 알려진 증편의 제조 조건에 따른 이화학적 변화를 실험하여, 가정에서 증편을 만들 때의 표준조건을 구명하려 하였다. 품질에 영향을 미치는 요인 중 쌀가루 입자의 크기는 발효에 의한 부피 증대에 영향을 미치지 않았으며, 설탕을 첨가하지 않으면 부피가 거의 팽창하지 않았다. 원료배합비는 쌀가루 : 탁주 : 설탕 = 10 : 5 : 2(w/v/w), 발효온도 35℃, 발효시간 3시간의 조건에서 부피 팽창이 가장 크게 일어났다. 발효된 반죽은 수증기로 찐 후에 평균 45~50%정도 부피가 줄어드나 4시간 이상 발효시킨 것은 80% 가까이 부피가 줄어 들었다. 부피 팽창이 가장 잘 일어나는 조건에서 발효시킨 반죽을 10~15분 쪄서 제조한 증편의 부피팽창율, 소화율(환원력, blue value, 호화도), 관능검사 및 Instron Texturometer에 의한 질감 검사가 가장 우수하였다. 즉 원료 배합비율은 쌀가루 : 탁주 : 설탕=10 : 5 : 2(w/v/w)이었고, 발효온도 35℃, 발효시간 3시간 , 찌는 시간은 10~15분이었다.