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Changes in Quality Characteristics of Brown Rice During Storage

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Abstract

The quality changes of brown rice during storage were determined by the method of quantitative analysis of n-hexanal, amylogram, texture and volume expansion. The qualities of stored brown rice were also analyzed with sensory evaluation of cooked milled rice obtained from brown rice. n-Hexanal content, peak viscosity and total setback of brown rice flour pastes increased substantially with the increase of storage period at 35°C. Up to 10 months of storage at 35°C, stale flavor obtained by a sensory method markedly increased, but stickiness decreased. The scores of overall preference were in good agreement with those of stale flavor ($r=-0.98$) and sticky texture ($r=0.98$). The correlation coefficient between stale flavor obtained by a sensory method and instrumental analysis of n-hexanal for stored brown rice was $r=0.97$.

Key words : quality, brown rice, storage

INTRODUCTION

Rice has been stored as paddy in Korea. Recently, the rapid increase of the amount of stored paddy rice caused storage problems in several regions because of the lack of warehouse[1-3]. The storage of brown rice, which is effective in reducing the volume of stored rice, was indicated to solve the lack of warehouses[2]. Thus, for the effective quality control of stored brown rice in Korean weather conditions, the detailed studies on the quality characteristics of stored brown rice were needed.

Studies on the quality characteristics of rice during storage have been carried out by several researchers[4-15]. Shin et al[4,5]. conducted a series of tests to develop a rapid and simple gas chroma-tographic method for determining n-hexanal, one of the main off-flavors, and to confirm the correlation between the oxidative deterioration of unsaturated lipids and the production of n-hexanal during storage of brown rice. Shin et al[6]. also reported the effects of amylase activity on changes in amylogram characteristics during storage of brown rice. But very little work has been done on the quality properties of brown rice during storage in Korea.

This study was undertaken to investigate the changes in the quality characteristics of brown rice during storage, and to compare their changes with sensory evaluation of cooked milled rice obtained from stored brown rice.

MATERIALS AND METHODS

Materials

Tongil brown rice (Samgangbyeo variety) was obtained by dehulling with a Satake dehuller (Satake Co., Japan). The brown rice was packed in polyethylene film bags and stored at 5℃ and 35℃ for 20 months. n-Hexanal of analytical standard grade was purchased from Poly Sciences (Warrington, PA).

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Analysis of n-hexanal

8g of brown rice were soaked in 125ml distilled water maintained at 25℃ for 30 min in a 250ml two-necked round bottom flask fitted with a 50 ml Liebig condenser and rubber septum. The flask was then dipped into water bath and the rice in the flask cooked at 98℃ for 40 min. 2ml of headspace vapor were removed with a 5ml gas tight Hamilton syringe inserted through the rubber septum into the headspace vapor over the cooked brown rice and injected immediately into a gas chromatograph (Hewlett-Packard Model 5840). Amounts of n-hexanal in headspace vapors were determined by the method of Shin et al[4].

Amylogram characteristics

The brown rice was milled to flour by passing through a 100 mesh sieve, and pasting properties of brown rice flours were measured with a Brabender Visco-Amylograph[16]. 40g (dry basis) of brown rice flour and 410ml of distilled water were well mixed and heated from 25℃ to 95℃, held at 95℃ for 60 min, and cooled to 50℃. Peak viscosity was the maximum viscosity during heating. Breakdown was peak viscosity minus final viscosity on cooking at 95℃. Total setback was viscosity on cooling to 50℃ minus final viscosity at 95℃.

Texture characteristics of cooked milled rice

Milled rice samples were obtained by polishing the brown rice by 8% (w /w) with a Satake milling machine (Satake Co., Japan). 20g of milled rice were put in a brass vessel (60 mm inner diameter ×30mm height). The milled rice was cooked in the oil bath at 100℃ for 30 min after the soaking for 30min with 30ml of distilled water at 25 ℃, and the vessel was cooled in ice water for 1 min. Hardness and stickiness of cooked rice were measured immediately by the texturometer (General Foods Co., U.S.A.) with the bulk of cooked rice[17]. The operation conditions of texturometer were as follows : plunger, lucite 18mm ; platform, 60mm × 30mm brass vessel ; voltage, 1.5V ; attenuator, 1.0 ;clearance, 0.25mm ; bite speed, high ; chart speed, 750mm/min.

Volume expansion of cooked brown rice

4g of brown rice and 8ml of distilled water were placed in a 30ml graduated test tube. The contents were stirred briefly with a wire to dislodge air bubbles and the tube was plugged with cotton and capped with a piece of paper. Several of these tubes were placed in a stand which was steamed at 0 psig in an autoclave for 45 min. Volume expansion was expressed as the difference between the final volume of cooked brown rice and the initial volume of brown rice plus water[10].

Sensory evaluation of cooked milled rice

200g of milled rice were placed in a beaker, washed and soaked in tap water for 1 hour at 25℃. The bulk of the water was removed by straining through a sieve. The rice was then transferred to an automatic electric rice cooker and water was added 1.2 times by weight of rice before hydration. After 10 min of cooking, sensory evaluation was carried out by a trained panel of ten members. A hedonic scale of 1 to 10 was used for the evaluation of cooked rice qualities of odor, flavor, texture, appearance and overall preference[18]. In determining the order of testing the samples, randomized block designs were used and three replications were made on each test for each sample[19].

RESULTS AND DISCUSSION

Instrumental evaluation

Results of the instrumental analysis of quality characteristics of brown rice during storage are given in Table 1. n-Hexanal content in headspace vapor was greater at 35℃ for 20 months storage than 5℃ for 20 months. Furthermore, then n-hexanal content increased in proportion to the storage period at 35℃ but slightly changed after 10 months of storage at 35℃. Brown rice stored at 35 ℃for 20 months exhibited a higher viscosity than that stored at 5℃ for 20 months. Peak viscosity and total setback of brown rice flour pastes also increased substantially with the increase of storage period at 35℃, but breakdown did not show significant changes during the same storage period. Shin et al[6]. suggested that the decrease in the amylase activity present in the brown rice during storage causes the increase in the amylogram peak viscosity of brown rice flour during the same storage period. Storage temper-ature and period

Table 1. Instrumental analysis of quality characteristics of brown rice during storage

Storage condition of brown rice	n-Hexanal[a] content (mg)	Amylogram viscosity (B.U.)			Hardness[b]	Stickiness[b]	Volume expansion (ml)
		Peak viscosity	Breakdown	Total setback			
20 moths at 5℃	0.145±0.012[c]	700±20	250±10	480±20	1.53±0.16	0.15±0.02	1.6±0.2
5 months at 35℃ followed by 15 months at 5℃	0.238±0.017	850±10	280±20	610±20	1.63±0.10	0.11±0.02	1.9±0.3
10 months at 35℃ followed by 10 months at 5℃	0.364±0.021	890±30	270±30	690±10	1.80±0.14	0.07±0.01	3.2±0.2
15 months at 35℃ followed by 5 months at 5℃	0.387±0.027	910±30	280±20	720±30	1.75±0.20	0.07±0.02	3.1±0.4
20 months at 35℃	0.339±0.025	920±40	310±30	810±20	1.85±0.12	0.06±0.01	3.3±0.3

[a] n-Hexanal content in 2ml headspace vapor.
[b] Textural characteristics of milled rice.
[c] *Mean ± SD based on 3 samples.*

Table 2. Sensory qualities of cooked milled rice obtained from brown rice stored in different conditions

Storage condition of brown rice	*Odor*		*Flavor*			*Texture*		*Appearance*			*Overall* preference
	Roasted nutty	Stale	Roasted nutty	Stale	Sweety	Watery	Sticky	Gloss	White-ness	Plump-ness	
20 months at 5℃	7.0[a]	2.5[a]	6.3[a]	2.2[a]	6.0[a]	6.2[a]	7.8[a]	8.7[a]	8.3[a]	7.4[a]	8.3[a]
5 months at 35℃ followed by 15 months at 5℃	5.0[b]	4.0[b]	4.6[b]	3.7[b]	4.0[b]	3.9[b]	4.5[b]	4.5[b]	6.0[b]	5.2[b]	5.5[b]
10 months at 35℃ followed by 10 months at 5℃	4.8[bc]	5.6[c]	4.5[b]	4.5[c]	3.7[b]	3.3[bc]	3.4[c]	4.2[b]	5.8[b]	5.0[b]	3.9[c]
15 months at 35℃ followed by 10 months at 5℃	4.8[bc]	5.8[c]	4.2[b]	5.0[c]	3.3[b]	3.2[bc]	2.9[c]	3.4[bc]	5.2[b]	4.6[b]	3.8[c]
20 months at 35℃	4.4[c]	5.4[c]	3.7[b]	5.1[c]	4.2[b]	2.3[c]	2.7[c]	3.0[c]	5.6[b]	4.7[b]	3.3[c]
F-value	3.06***	1.63*	3.74***	2.76***	3.84***	3.74***	7.18***	7.30***	4.59***	4.78***	7.26**

1) Each mean consisted of 30 judgements with 10 panelists. Mean within columns followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.
2) F-value was calculated by analysis of variance.
3) * : $p<0.05$, ** : $p<0.01$, *** : $p<0.005$.

affected texturometer values of hardness and stickiness of cooked milled rice obtained from stored brown rice. With the increase of storage period at 35℃, stickiness gradually decreased, but hardness did not show significant changes. Volume expansion of cooked brown rice stored at 35℃ for 5 months followed by at 5℃ for 15 months was greater than that of the sample stored at 5℃ for 20

months. But volume expansion of samples did not change after 5 months of storage at 35℃.

Sensory evaluation

Results of the sensory evaluation of cooked milled rice, obtained from brown rice stored at different condition, are given in Table 2. Variation in odor, flavor, texture and appearance were noted among brown rice stored at different temperatures. The lots of rice stored at 35℃ for 20 months tended to be more stale in flavor than the sample stored at 5 ℃ for 20 months. Yasumatsu et al[12] . reported that alkanals formed by the autooxidations of free unsaturated fatty acid during storage caused the off-flavor of old rice after cooking.

On the other hand, cooked milled rice obtained from brown rice stored at 35℃ showed a lower value in whiteness than that of the brown rice stored at 5℃. This result is also in good agreement with the results of Pelshenke[10] in that milled rice stored at 2℃ and 20℃ undergoes very little change, but all types develop a marked yellow color at 35℃. In the meantime, as the storage period at 35 ℃ increased, the stickiness and overall prefer-ence scores of cooked milled rice markedly decreased until 10 months of storage. But their values did not significantly change after 10 months of storage at 35℃. The scores of overall preference were in good agreement with those of stale flavor ($r=-0.98$) and sticky texture($r=0.98$). These results mean that the samples which showed high overall preference were sticky with less stale flavor, and are also in good agreement with the results of Kim et al[18] .

The correlation coefficient between stale flavor obtained by a sensory method and instrumental analysis of n-hexanal for stored brown rice is $r=0.97$. These results show that the analytical method of n-hexanal in headspace vapor over cooked brown rice by direct vapor injection gas chromatographic method can be partly used to measure the stale flavor of stored brown rice.

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저장중 현미의 품질 특성 변화

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요 약

본 연구에서는 저장 현미의 품질 판정에 필요한 기초 자료를 얻기 위해, 저장중 현미의 품질에 직접적으로 영향을 주는 고미취 및 조직 변화를 기계적 방법 및 관능 검사를 통하여 정량적으로 비교 분석하였다. 기계적 측정 항목중 고미취의 주성분인 n-헥산알 그리고 아밀로그램의 최고점도 및 total setback값 등은 35℃에서 저장된 기간이 길수록 각각 높은 값을 보여 주었다. 관능적 특성에 대한 강도 평가시 35℃에서 저장된 기간이 길수록 고미는 증가하고 끈적거림은 감소하였으나, 10개월부터는 유의한 차이를 보여주지 않았다. 그리고 고미가 약하고 끈적거림이 강한 취반미일수록 선호도가 높은 경향을 보여주었다. 한편 가스크로마토그라피 방법으로 정량한 n-헥산알 양과 관능 검사에 의한 고미(stale flavor)는 높은 상관 관계를 보여 주어(r =0.97) 직접 증기 주입법에 의한 n-헥산알 정량 방법은 저장중 현미의 고미 정도를 예측할 수 있는 가능성을 보여 주었다.