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อิทธิพลร่วมของปัจจัยการบรรจุหีบห่อต่อคุณภาพความหอมของข้าวสาร พันธุ์ขาวดอกมะลิ 105 หลังการเก็บรักษาระยะนาน

Interaction of packaging parameters affecting aroma quality of milled rice cv. Khao Dawk Mali 105 after long-term storage

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Abstract

This study was to investigate the interactive effects of packaging parameters on aroma quality of milled rice cv. Khao Dawk Mali 105 after storage for 12 months under ambient temperature. Rice samples were packaged using combinations of two packaging materials, three kinds of gas and with or without an oxygen absorber. Aroma quality of rice samples was assessed in terms of 2-acetyl-1-pyrroline and hexanal quantities. It was found that aluminum foil laminated bag had higher efficiency in preserving 2-acetyl-1-pyrroline and in controlling the generation of hexanal than nylon laminated plastic bag. Using oxygen absorber enhanced the ability of the packages to preserve 2-acetyl-1-pyrroline and to prevent the increase of hexanal. Carbon dioxide was better in maintaining high 2-acetyl-1-pyrroline and low hexanal in rice package as compared to nitrogen and vacuum packed. Analysis of variance indicated that there were interactions of packaging materials-oxygen absorber and packaging materials-storage gas. These interactions were mainly attributed to difference in gas permeability of the packaging materials. Relationship between the quantity of 2-acetyl-1-pyrroline and hexanal was found only for samples contained in nylon laminated plastic bag (r = -0.88**). This result signified the role of oxygen in which it would mutually increase hexanal and decrease 2-acetyl-1-pyrroline quantities during storage of aromatic rice.

Keywords: Oxygen absorber, packaging material, storage gas

บทคัดย่อ

การศึกษามีวัตถุประสงค์เพื่อวิเคราะห์อิทธิพลร่วมของปัจจัยการบรรจุหีบห่อต่อคุณภาพความหอมของข้าวสารพันธุ์ขาวดอกมะลิ 105 หลังเก็บรักษาในสภาพอุณหภูมิห้องปกตินาน 12 เดือน ตัวอย่างข้าวถูกเก็บรักษาด้วยปัจจัยผสมระหว่างวัสดุบรรจุภัณฑ์ 2 ชนิด ก๊าซ 3 แบบ ร่วมกับการใช้และไม่ใช้สารดูดออกซิเจน คุณภาพความหอมของข้าวประเมินโดยวิเคราะห์ปริมาณสารหอม 2-อะเซติล-1-พิรโรลีน (2-acetyl-1-pyrroline) และสารก่อเกิดกลิ่นหืนเฮ็กซาแนล (hexanal) การทดลองพบว่าถุงอลูมิเนียมฟอล์ยลามิเนตมีประสิทธิภาพในการรักษา 2-อะเซติล-1-พิรโรลีน และป้องกันการเกิดเฮ็กซาแนลได้ดีกว่าถุงพลาสติกไนลอนลามิเนต การใช้สารดูดก๊าซออกซิเจนในภาชนะบรรจุช่วยเพิ่มประสิทธิภาพการรักษา 2-อะเซติล-1-พิรโรลีน และป้องกันการเกิดเฮ็กซาแนลได้ดีขึ้น และพบว่าการบรรจุก๊าซคาร์บอนไดออกไซด์มีผลต่อการถนอม 2-อะเซติล-1-พิรโรลีน และลดการเกิดเฮ็กซาแนลได้ดีกว่าการบรรจุแบบเติมก๊าซไนโตรเจนและแบบสุญญากาศ การวิเคราะห์ความแปรปรวนพบอิทธิพลร่วมระหว่างวัสดุบรรจุภัณฑ์กับสารดูดก๊าซออกซิเจน และวัสดุบรรจุภัณฑ์กับก๊าซ ซึ่งเป็นผลจากความสามารถที่ต่างกันในการควบคุมการผ่านก๊าซของวัสดุบรรจุภัณฑ์ การพบความสัมพันธ์ ระหว่างปริมาณ 2-อะเซติล-1-พิรโรลีน และเฮ็กซาแนล เฉพาะตัวอย่างที่บรรจุถุงพลาสติกไนลอนลามิเนต (r= -0.88**) แสดงให้เห็นว่าก๊าซออกซิเจนมีอิทธิพลต่อการเพิ่มขึ้นของเฮ็กซาแนลและอาจมีผลต่อการลดลงของ 2-อะเซติล-1-พิรโรลีน ในข้าวหอมระหว่างการเก็บรักษา

คำสำคัญ: สารดูดออกซิเจน วัสดุบรรจุภัณฑ์ ก๊าซเก็บรักษา

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Introduction

Aroma of rice plays an important role in consumer acceptability. Nevertheless, rice sales in market have to be stored for a certain period of time and its aroma quality decrease. Quantity of 2-acetyl-1-pyrroline, the key aroma impact compound of rice cv. Khao Dawk Mali 105 was reported to be rapidly reduced by fifty percent in three months after harvest (Wongpornchai *et al*., 2004). Processing of milled rice, on the other hand, disrupts lipid bodies of rice bran layer and retains some of its residual on surface of the milled rice kernel. This residual is rapidly oxidized by lipid hydrolysis enzyme or auto-oxidation processes, resulting in the development of key off-odor compounds including hexanal, in the stored milled rice. This information was importance for post-harvest management of fragrant rice since the unique aroma of rice depends on amounts of the existing volatile compounds (Widjaja *et al*., 1996). To maintain aroma quality of rice, high quantity of 2-acetyl-1-pyrroline has to be preserved whereas the production of hexanal must be restricted. Of this particular importance, appropriate packaging measures utilizing oxygen barrier packaging materials and gas storage techniques such as vacuum, carbon dioxide and nitrogen, as well as oxygen absorbers to preserve high 2-acetyl-1-pyrroline and low hexanal quantities in the stored aromatic milled rice were investigated and their interactive effects were also examined.

Materials and Methods

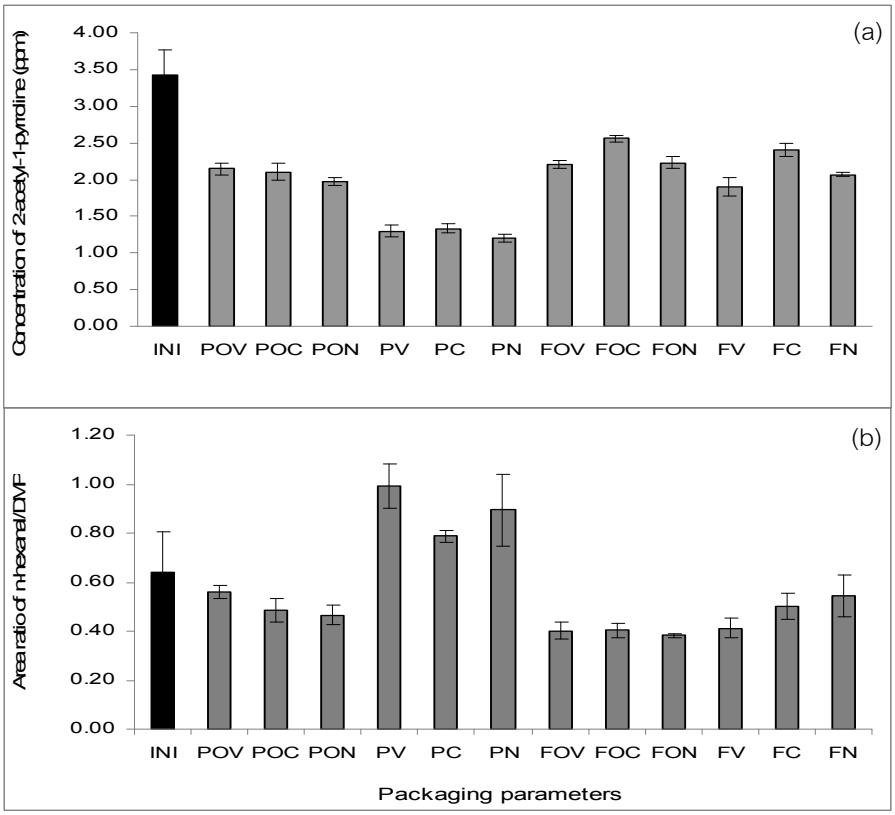
Milled rice samples cv. Khao Dawk Mali 105 were packaged, 500 g each bag, using combinations of two packaging materials (nylon laminated plastic bag and aluminum foil laminated bag), three types of storage gas (vacuum, carbon dioxide and nitrogen) and with or without using an oxygen absorber. After storage under ambient temperature for 12 months, concentrations of 2-acetyl-1-pyrroline and relative amounts of hexanal of rice samples was determined using the headspace-gas chromatography (HS-GC) method developed by Sriseadka *et al*. (2006). The experimental design was 2x3x2 factorial in CRD. Data collected were subjected to analysis of variance (ANOVA) and least significant difference (LSD) test was done to separate the means ($P<0.05$).

Results and Discussion

The concentration of 2-acetyl-1-pyrroline and hexanal of aromatic milled rice contained in different packaging parameters and stored under ambient temperature for 12 months are shown in Figure 1. Comparison within each packaging parameter revealed that aluminum foil laminated bag, carbon dioxide packed and oxygen absorber were better in retaining 2-acetyl-1-pyrroline in rice samples than their corresponding parameters. Aluminum foil laminated bag and oxygen absorbers were also effective in preventing the generation of hexanal in rice bags. Data clearly indicated that combination of aluminum foil laminated bag-carbon dioxide packed-with using an oxygen absorber were the most efficient packaging measure for quality preservation of this aromatic rice comparing to other packaging parameter combinations. Determination of 2-acetyl-1-pyrroline and hexanal quantities in rice samples after storage for 12 months showed that 74.9 percent of 2-acetyl-1-pyrroline was reserved in rice contained in this combination packaged while the amounts of hexanal was reduced by 36.9 percent, as calculated with their respective initial values.

Analysis of variance (Table 1) indicated that there were interactive effects of packaging materials-storage gas and packaging materials-oxygen absorber on the amounts of 2-acetyl-1-pyrroline and hexanal in stored milled rice. These interactions were mainly attributed to difference in gas permeability of the packaging materials. Lesser barrier property to oxygen of nylon laminated plastic bag, in comparison with aluminum foil laminated bag, might promote hexanal production as amount of oxygen in this packaging was more available for oxidation process. Inclusion of an oxygen absorber to this packaging type thus reduced amount of oxygen resulting in lower quantity of hexanal. Oxygen absorbers based on iron (Fe^{2+}) oxidation are widely used in active packaging and have been utilized successfully in quality preservation of various agricultural and food products (Jensen *et al*., 2003; Mexis

and Kontominas, 2010). In this study, obvious effect of oxygen absorber in the conservation of rice aroma was demonstrated. Correlation analyses between the quantities of 2-acetyl-1-pyrroline and hexanal of overall and subset data were made and the results are shown in Table 2. Strong relationship (r = -0.84**) was found when all data was calculated. However, with separation of packaging materials data, it was found that the association was mostly contributed by data from samples contained in nylon laminated plastic bag (r = -0.88**). This information indicates that oxygen absorber had a more marked effect on the packaging with inferior in oxygen impermeability, leading to the conclusion that interactions between packaging materials and storage gas or oxygen absorber were predominantly attributed by difference in gas diffusion property of the packaging types.



INI = concentration of 2-acetyl-1-pyrroline before storage
Packaging parameters:
P= nylon laminated plastic bag; F= aluminum foil laminated bag; O= oxygen absorber;
V= vacuum packed; C= carbon dioxide gas packed; N= nitrogen gas packed

Figure1 Concentration of 2-acetyl-1-pyrroline (a) and relative amount of hexanal (b) in milled rice cv. Khao Dawk Mali 105 after storage in different packaging parameters for 12 months under ambient temperature.

Table 1 Analysis of variance showing source of variation and probability.

Source of variation	Probability	
	2-acetyl-1-pyrroline	hexanal
Packaging materials	**	**
Storage Gas	**	ns
Oxygen absorber	**	**
P x G	**	**
P x O	**	**
G x O	ns	ns
P x G x O	ns	ns

**= Significant at P<0.01, ns= not significant.

Table 2 Correlations (*r*) between 2-acetyl-1-pyrroline and hexanal quantities of milled rice stored under different packaging materials, storage gas and with or without using oxygen absorber.

Packaging parameters	Correlations (*r*) 2-acetyl-1-pyrroline and hexanal
Overall data	-0.84**
Nylon laminated plastic bag (data subset)	-0.88**
Aluminum foil laminated bag (data subset)	-0.09

**= Significant at P<0.01.

Summary

All the packaging parameters studied had roles in rice aroma quality preservation and their effects were interrelated. Considerations on this experimental data should be taken for the long-term storage of aroma rice and it is recommended that aluminum foil laminated bag-carbon dioxide packed-with using an oxygen absorber should be employed.

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Literature cited

Jensen, P. N., G. Sorensen, P. Brockhoff and G. Bertelsen. 2003. Investigation of packaging systems for shelled walnuts based on oxygen absorbers. J. Sci. Food Agric. 51: 4941-4947.

Mexis, S. F. and M. G. Kontominas. 2010. Effect of oxygen absorber, nitrogen flushing, packaging material oxygen transmission rate and storage conditions on quality retention of raw whole unpeeled almond kernels (*Prunus dulcis*). LWT - Food Sci. Technol. 43: 1-11.

Sriseadka, T., S. Wongpornchai and P. Kitsawatpaiboon. 2006. Rapid method for quantitative analysis of the aroma impact compound, 2-acetyl-1-pyrroline, in fragrant rice using automated headspace gas chromatography. J. Agric. Food Chem. 54: 8183-8189.

Widjaja, R., J.D. Craske and M. Wootton. 1996. Changes in volatiles components of paddy, brown and white fragrant rice during storage. J. Sci. Food Agric. 71: 218-224.

Wongpornchai, S., K. Dumri, S. Jongkaewwattana and B. Siri. 2004. Effects of drying methods and storage time on the aroma and milling quality of rice (*Oryza sativa* L.) cv. Khao Dawk Mali 105. Food Chem. 87: 407-414.