PT-10

EFFECT OF PACKAGING AND STORAGE TEMPERATURE ON QUALITY ATTRIBUTE OF ORGANIC BROWN RICE

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ABSTRACT

Thai organic browning rice productivity is growing especially in a small and community business but lacking of a proper packaging for storage. Therefore, the objective was to evaluate the effects of packaging and storage temperature on the storage qualities. Rice samples were packed using gunny sack (GS, control) polypropylene woven (PP-woven) sack, low density polyethylene (LDPE) and LDPE-vacuum which stored at room temperature, RT (32±3^{o}C) and freezer, FT (-16±1^{o}C). During storage at both temperatures, lightness and flavour quality were evaluated at one month interval for five months. At RT, lightness of GS sample increased more than PP-woven, LDPE and LDPE-vacuum. After five months, examiners could identify the differences in flavour between cooked samples stored in different packagings. Lightness slightly increased when stored in freezer using LDPE and LDPE-vacuum comparing to PP-woven and GS. There was a significant difference (P = 0.05) in flavour of cooked LDPE and LDPE-vacuum samples comparing with GS. There was no significant different (P = 0.05) observed between sample stored by PP-woven and GS. Overall, freezing storage with LDPE and LDPE-vacuum could be possible to extend shelf life.

Keyword: Freezing storage, LDPE, Polypropylene, Eating quality, Lightness

INTRODUCTION

Thai Ministry of Commerce reported the production of Thai organic brown rice was produced with the international market value being US $10M and organic market is growing regularly [2]. Increasing of export market of organic brown rice was also report. Organic rice has been introduced to Thai farmer more than two decades. Organic farm-ing aims to minimize chemicals sprays and production costs with heal-thy farmer. It was reported that higher production rate per area and higher returns can be achieved by organic rice farming [18]. However, small farmer needs to expand their business to modern trade in order to increase their outcome [1].

Brown rice is manufactured by dehusking without any removing bran layers. Rice bran composes of pericarp, aleurone layer, germ and a part of endosperm (starch) and also it contains of minerals, vitamins, dietary fibre, fat and some useful chemicals [9,15,5,11]. Rice bran can be used to produce vegetable oil for human consumption.

Storage quality of brown rice is limited by lipids and nutritional components resulting in spoilage [11]. During storage lipase presented in rice bran hydrolyzes its fats into free fatty acids and glycerol [4]. At high temperature and high grain moisture cause free fatty acids to increase quickly. Additionally, mold growing accelerate further fat decomposition resulting in generation of stale flavour in old rice [4], off-odors and taste and loss of nutrition [20].

Storage conditions such as environmental conditions and treatments applied to grain during storage affect the quality of grain during storage [13]. Generally, storing rice in gunny or polypropylene-woven bags in the convenient warehouse are applying in the developing countries. However, this could subject to losses to pests, insects, mites and high humidity in the warehouse and result in qualitative, quantitative and nutritive losses.

Hermetic storage of grains is an airtight condition in which mold growth and insect population are limited by natural accumulate of carbon dioxide and depletion of oxygen by the grain and organism respiration [13]. Low density polyethylene (LDPE), high density polyethylene (HDPE) and polyvinyl chloride materials are used to manufacture plastic bin for grain storage [4]. Additionally, laminated plastic films for example oriented polypropylene/aluminium/linear low-density polyethylene and nylon /linear low density polyethylene are used to pack organic milled rice and fortified rice, organic rice and fragrant rice [16-17]. Bag storage has merits of cheaper storage cost and handling and also can be minimized the effects of humidity and temp-erature in compar-ison to bulk storage [4]. Nevertheless, bag storage has shorter storage period comparing to bulk storage. Sealed packaging could minimize the uptaken moisture during storage resulting in decline of live insects and maintaining grain quality [14]. Vacuum pack is low oxygen pack which could minimize the growth of insects and pests resulting in maintain organic rice quality [17].

Chilled storage is being used in temperate and tropical countries especially brown rice due to low temperature slow down chemical and biochemical reactions [4]. On the other hand, cool storage system adds more expense to the system even more operating cost for storage by freezer. Storage at low temperature is usually advantage in less insecticide degradation resulting in less insecticide application [13]. Storage at temper-ature below 5 and 15^{o}C can prohibit mite and insect development [4]. Otherwise, tempera-ture at 20^{o}C causes occupation of insects and microorganisms and rapid deterioration of chemical constituents. Temperature and time are the crucial parameters influencing storage quality [17]. Storing rice at high temperatures (30-40^{o}C) reduce pH, turbidity and solids content but increased hardness and fatty acidity in comparison to 4^{o}C storage [23,8]. Storage cereal at 10^{o}C was reported to main-tain quality and it was suggested that cereal grains should not be store at more than 25^{o}C in order to minimize nutritional losses [6].

Presently, Thai small-farming still needs to educate on the appropriate storage condition to store their rice product. Additionally, there are limit number of research related to orga-nic brown rice. Basically, farmer store rice in gunny sack at ambient temperature which results in changes in quality attributes. This research aims to investigate the effect of packaging and storage temperature on quality attribute of organic brown rice. Moreover, result from current study could be able to increase small farmer's chance to upgrade their business to the modern trade.

MATERIALS AND METHODS

Rice sample preparation

Organic brown rice paddy about 300 kg was received from farmer located at Pimai, Nakhonratsima, Thailand. Thereafter, organic brown rice was produced by local rice mill plant and transported to Post-Harvest and Processing Engineering laboratory by vehicle at ambient temperature.

Storage bags

LDPE (0.15 mm thickness, 8 x 12 in$_2$), PP-woven sack (4 x 6 in$_2$) and gunny sack were purchased from local scientific supplier.

Storage temperature conditions

Two sets of organic brown rice were prepared by weighing (one kg per bag, 20 bags per treatments) and storing in LDPE, LDPE-vacuum and PP-woven sack at room temperature, RT (32+3^{o}C) and FT (-16+1^{o}C) using freezer (TCF 65 WHC, Singer, Thailand) for 5 months. Control was set up by storing organic brown rice in gunny sack (GS). LDPE-vacuum was done using vacuum packer (VP438, Ramon, Spain) at conditions of scale 5 for vacuum control and scale 3 for sealer.

Quality evaluation

Lightness changes of lightness of sample during storage (one month interval) were evaluated by The Center for Scientific and Technology Equipment, Suranaree University of Technology (SUT), Nakhonratsima using chromameter (CR 300, Minalta, Japan).

Fat content Changes of fat content during storage (one month interval) was determined using AOAC, 32.1.14 [3] at Postharvest and Processing Research and Development Division, Department of Agriculture, Ministry of Agriculture and Cooperative, Bangkok.

Cooking quality (flavour) Every month of storage, sample was randomly selected and cooked using rice cooker (ot-cr-100t, OTTO, Thailand). Cooking recipe was one standard cup (250 g) of rice sample per 750 ml of water. The cooked rice samples were analyzed for sensory quality. A hedonic scale (0 = extremely same, 7 = extremely different) ranking test and quality descriptive analysis was applied to evaluate consumer preference among cooked rice samples. Panelists were asked to rank the samples in the order of preference for given attribute comparing with control sample. The four samples were served in order to each panelist. Samples (20 g) were close to room temperature (32-35ºC) and panelist rinsed their month with distilled water before testing each sample. The panel was asked to evaluate samples in order of odor, texture and flavour.

Data analysis

All statistical analyses were performed using the Statistical Analysis System (version 9.2 (TS2M3), SAS Institute Inc., Cary, NC, USA.). Data were analyzed by analysis of variance (ANOVA). Comparison of means was performed by using standard error, standard deviation and least significant difference to evaluate significant differences at P = 0.05.

RESULTS AND DISCUSSION

Changes in lightness

The lightness of sample stored by different packaging increased in overall during storage at RT and FT (Fig.1 and Fig.2). Lightness of sample stored at RT was slightly higher (45-52) than that stored at FT (45-49). After a month at RT storage, the lightness increased significantly and showed high values on the second and the third storage months (Fig.1). Sample stored by GS showed higher values than entire of storage. After 5 months of storage, the maximum lightness was observed in sample stored by GS whilst the lowest value was observed in sample kept in PP-woven. There was no significant lightness change in LDPE samples during stored for 1 to 3 months. Then, it reduced significantly and found no significant change until the end of storage. Sample stored by LDPE-vacuum displayed no significant lightness changes during stored for 2 to 4 months and decreased after 5 months. It was found that there was correlation (0.604) between lightness and storage temperature (35ºC) during storing brown rice [21]. This study also concluded that change of physicochemical properties of milled brown rice stored at 15ºC was lower than 35ºC.

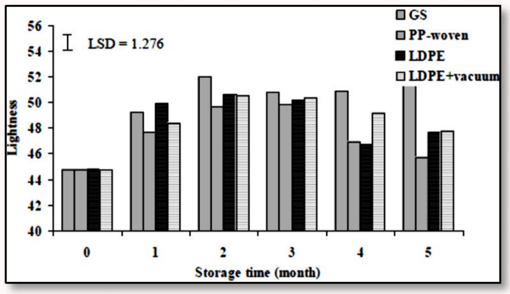

Fig.1 Changes of lightness of organic brown rice sto-red by different types of packaging during stor-age for 5 months at room temperature (32±3 ºC)

It was observed slightly increased lightness in all sample stored at FT (Fig.2). There was no significant lightness change in all samples after stored for 2 months. Whist it was found significant reduce after store for 3 months in sample stored by LDPE and LDPE-vacuum. At the end of storage, there was no significant diffe-rent in lightness of all samples.

After storage for 5 months, all samples stored at FT had smaller changes in lightness and observed slightly change in lightness in sample stored by LDPE and LDPEvacuum. Storing brown rice at 4ºC could retard physical and chemical degradation at slower rate in comparison to store at higher temperatures (25 and 37ºC) [8].

Additionally, super-low temperature (below freezing point) was reported to maintain physiological properties of rough rice [12]. However, the increasing of lightness observed by this study was unlike with the result report by studies [7,8].

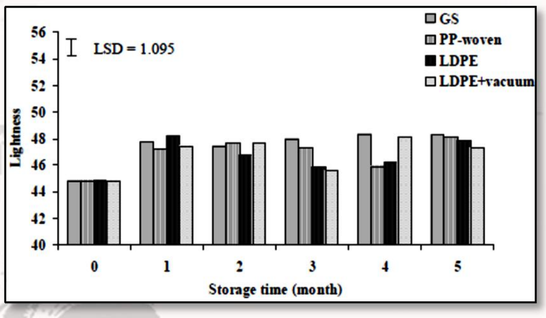

Fig.2 Lightness changes of organic brown rice stored by different types of packaging during storage for 5 months in freezer (-16±1ºC).

Changes in fat content

Fat content show fluctuation during 5 months of storage at RT (Fig.3) while sam-ples stored at FT showed overall increasing trend

(Fig.4). The maximum fat content was found in sample stored by LDPE at FT after 4 months.

Fat content increased in all samples after 2 months of RT storage except sample stored in LDPE-vacuum. GS and LDPE storages showed high fluctuation of change in fat content during storage at RT. Fat content of sample stored by PP-woven illustrated consistently increased and decreased during storage and showed low level of fat content at the end of storage. Whilst, there was high level of fat content found from sample stored in LDPE-vacuum after 5 months.

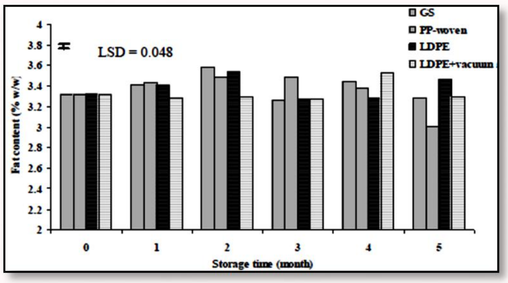

Fig. 3 Changes of fat content of organic brown rice during storage for 5 months at room temperature (32±3°C) with different types of packaging.

Changes in fat content during brown rice storage could be affected by high temperature storage. It was found that there was correlation (0.604) between fat acidity and storage temperature (35°C) during storing brown rice [21]. High ambient temperature with high relative humidity could reduce grain quality during storage period that influence milled rice quality [14]. Samples stored at FT showed consistent increase fat content (Fig.4). LDPE sample showed the highest fat content after 4 months and the lowest after 5 months. During first 3 months of storage, there was smaller increase in fat content in LDPE and LDPE-vacuum samples in comparison to other treatments.

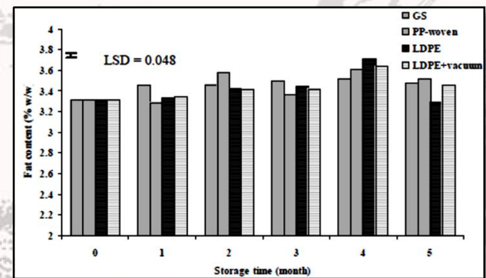

Fig.4 Changes of fat content of organic brown rice during storage for 5 months at -16±1°C with different types of packaging.

Sample stored in LDPE-vacuum tend to have smaller change in fat content in comparison to other treatments at FT. Low temperature accompany with vacuum packaging was reported to retard changes in physicochemical qualities of organic hulled rice that stored at ambient temperature and 15°C [17]. Also it was reported that under controlled atmo-sphere storage had lower rate of fatty acid value change in brown rice in comparison to conventional storage at high temperature [19]. Storing brown rice at 15°C using LLD-PE could retard of volatile lipid oxidation and maintained desirable odorants [16]. However, storing brown rice in LLDPE and nylon resulted in great extent and higher rate of undesirable changes in volatile compounds when store at ambient temperature [16]. The higher storage temperature could result in increasing of free fatty acid of brown rice sample [7] and milled rice [8].

Changes in flavour quality

Flavour quality of cooked sample displayed significant differences over traditional storage (GS) at RT (Fig.5). Samples stored at FT showed larger variation of flavour quality in all samples (Fig.6). It seems the difference of flavour of cooked sample was small in sample stored at FT in comparison to RT.

During 5 months of storage, mean values of flavour score of cooked sample were found significant differences when stored at RT (Fig.5). It was found increasing of the differences of flavour of cooked rice between GS comparing with other treatments. The difference between GS storage and other storages was obviously found at the end of storage. The highest mean value of flavour of cooked sample was found in sample stored by LDPEvacuum after 5 months of storage.

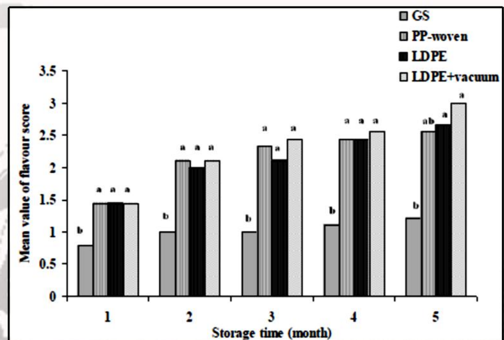

Fig. 5 Changes in flavour quality of organic brown rice during storage for 5 months at room

temperature (32±3°C) which stored in different types of packaging.

Flavour of PP-woven cooked sample stored for 1 month at FT was found higher than other samples (Fig.6). After 3 months at FT storage, the mean values of flavour score of PP-woven, LDPE and LDPE-vacuum cooked samples was very similar. The mean value of LDPE-vacuum cooked sample was found higher than other samples after stored for 4 months. After 5 months of storage, it was found that LDPE and LDPE-vacuum cook samples showed significant differences of flavour in comparison to GS and PP-woven.

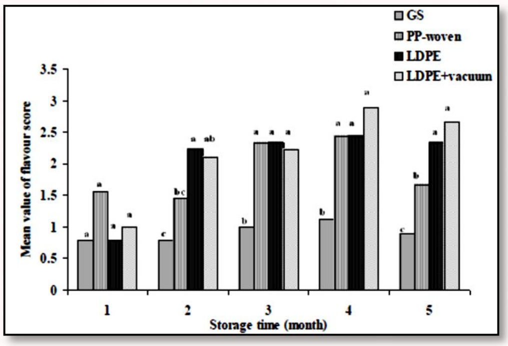

Fig.6 Changes in quality of organic brown rice during storage for 5 months at -16±1°C which stored in different types of packaging.

There were significant differences of entire samples comparing with GS either store at RT or FT. It seems that after 5 months of storage the flavour of LDPE-vacuum cooked sample was far difference from GS in comparison to other treatments in both temperatures. When consider changes in fat content of LDPE-vacuum, it was found small changes in both storage temperatures. This could be said that LDPE-vacuum could maintain flavour of rice sample at FT.

The cooking quality of cooked milled brown rice stored at 15°C was higher than 35°C [21]. More acceptable to sample stored at lower temperature was reported [23,8,7]. Longer storage cooked rice was less acceptable [17,22]. However, freezing storage was reported to maintain eating quality of rough rice [12].

CONCLUSIONS

Types of packaging and storage temperature had significant effects of physicoche-mical properties and cooking quality of organic brown rice (P = 0.05). Changes in lightness was found at RT in all sample while smaller change was found from all samples stored in FT. Increasing fat content was observed uncertain change in sample stored at RT than FT. However, it seems that fat content of sample stored using LDPE-vacuum at RT had lower changes. Flavour quality show large significant different (P = 0.05) in sample stored using LDPE-vacuum at both temperature. Hence, storing organic brown rice at low temperature using LDPE-vacuum pack could retard quality deteriora-tion. Cost related to RT or FT application should be concerned as it plays an important role to the system. The outcome of this study could provide useful information for small farmer to extend organic brown rice physico-chemical properties and cooking quality on the purpose of broader market.

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