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Contributed Paper

Effects of Packaging Types and Storage Temperatures on the Shelf Life of Fresh Rice Noodles under Vacuum Conditions

Pornchai Rachtanapun* and Thitima Tangnonthaphat
Division of Packaging Technology, Faculty of Agro-Industry, Chiang Mai University, 50100, Thailand.
*Author for correspondence; e-mail: p.rachta@chiangmai.ac.th

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ABSTRACT

The effects of packaging type and storage temperatures on the shelf life of fresh rice noodles were investigated. Fresh rice noodles were packed in four different packaging types; high density polyethylene (HDPE) wrap, high density polyethylene pouch, polyethylene terephthalate (PET) pouch and nylon pouch under vacuum condition and stored at 25°C. The shelf life of fresh rice noodles was determined by sensory evaluation for selecting the suitable packaging material. Microbiological properties and pH of samples in different packaging types were also investigated. The results showed that samples in the nylon pouch had the longest shelf life (13 days) compared to other packaging materials. Therefore, nylon pouches were chosen to study the effect of storage temperatures (4°C and 25°C) on the shelf life of fresh rice noodles under vacuum conditions. Microbiological and texture properties of these samples were determined. It was found that samples stored at 4°C gave a longer shelf life than that stored at 25°C. Low temperatures (4°C) could inhibit the growth of microbes and slow down the decrease in pH. However, the shelf life of fresh rice noodles was only 29 days due to retrogradation.

Keywords: noodle, shelf life, packaging and storage temperature.

1. INTRODUCTION

Rice noodles are a popular traditional food produced from rice in Thailand which is also known as rice vermicelli and is served across Asian and Europe countries. Rice noodles can be found in a wide variety of shape and sizes; thick and thin, flat and round, long and short.

The shelf life of rice noodles and its quality were affected by the storage conditions and the manufacturing process of rice noodles, especially for fresh rice noodles, because fresh rice noodles are a type of noodle that are usually made locally. Fresh rice noodles have a high moisture content (62.51%) and a_w (0.91) so its shelf life is relatively short, only 2 – 3 days. There have been many research projects involved in how to extend the shelf life of fresh rice noodles.

Jianming who studied the preservation of fresh noodles by irradiation showed that the noodles that were irradiated with 10 kGy of 60Co - gamma rays and then kept at 18 – 24°C could be stored for 10 days [1]. And the higher the radiation dose, the fewer bacteria survived and the extent of acidification also decreased [1]. Likewise, Puttongsiri studied the preservation of fresh rice noodles using the hurdle technology [2]. In this method, noodles were soaked in 1% citric acid, packed in polypropylene bags, and then heated at 100°C for 10 minutes and kept at 12°C storage. The results showed that it could be stored for 2 months [2].

However, there is little research involved in the preservation of fresh rice noodles by using appropriate packages. Therefore, the objectives of this study were to determine the effects of packaging type and storage temperature on the shelf life of fresh rice noodles.

2. MATERIALS AND METHODS

2.1 Materials

Fresh rice noodles were donated by Itsariyaphon industry, Chiang Mai, Thailand. Four different packaging types were evaluated with regard to their potential effect on shelf life. The four packaging types include HDPE wrap (size 18.25" × 18.25", thickness 25 μm), HDPE pouch (size 6" × 6.71", thickness 40 μm), PET pouch (size 5.5" × 7.12", thickness 50 μm, and nylon pouch (size 5.19" × 7.44", thickness 80 μm)

2.2 Determining Oxygen Permeability and Water Vapor Permeability of the Packaging Materials

In this study, there were 4 types of packaging materials; HDPE wrap, HDPE pouch, PET pouch, and the nylon pouch as shown in Figure 1. The packaging materials were cut into circular shapes with a diameter of 10 centimeters and placed into the permeation analyzer. The oxygen permeability (OP) of all packaging materials was determined following ASTM D1434-82, 2003 [3] at 25°C using a gas permeation analyzer (Model: VAC-V1, M&E Technology Co. Limited, China). The water vapor permeability (WVP) of all packaging materials was determined following ASTM D6701, 2001 [4] at 25°C using water vapor permeation analyzer (Model: 7000, Illinois Instruments, Inc., USA). All samples were performed with 3 replications.

2.3 Sensory Evaluation

According to the Thailand Industrial Standard No. 832-2005, color, texture, flavor and overall acceptances are all important sensory parameters for quality evaluation of fresh rice noodles. Fresh rice noodles in all packaging materials were evaluated by 20 panelists using quality rating method as shown in Table 1.

2.4 Determining Microbiology Analysis

In this study, bacterial counts were determined using the pour plate method following FDA-1995 [5]. The initial dilution was made by aseptic blending in a Stomacher for 60 s, 25 g of sample with 225 ml 1g/l peptone solution. Appropriate serial dilutions were plated with plate count agar (PCA) (M091, HiMedia Laboratories Prt. Ltd., India) for total microbes, with potato dextrose agar (PDA) (M096, HiMedia Laboratories Prt. Ltd., India) for yeast and mold, and with cereus selective agar (Model: 22310, *Bacillus Cereus* Selective Agar, Mannitol-Egg-yolk-Polymyxin-Agar, M.Y.P.-agar, PREP agar, *Bacillus cereus* Egg yolk Polymyxin Agar Base, Fluka Chemie GmbK CK-9471 Buchs, Switzerland) for the *Bacillus sp.* All samples were incubated at 37°C for 2-3 days. Collected data were expressed as log colony forming

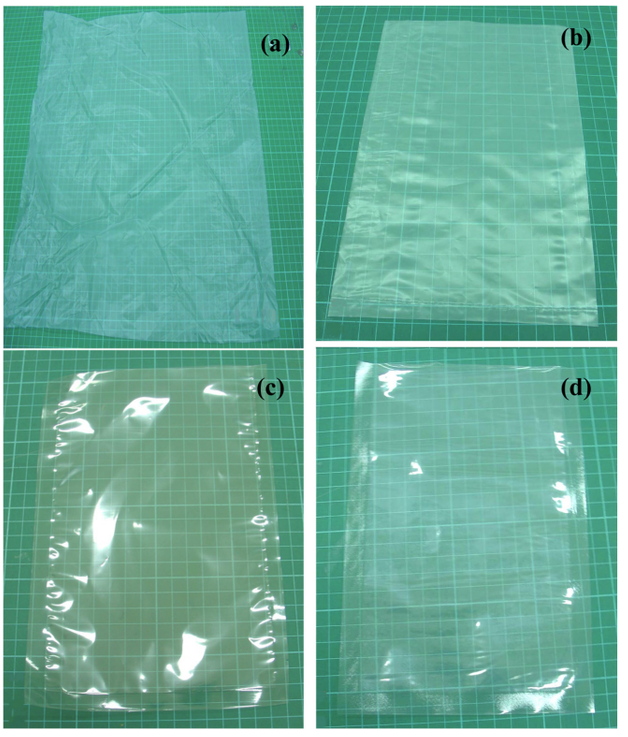

Figure 1. Packaging materials for packing fresh rice noodles
(a) HDPE wrap, (b) HDPE pouch, (c) PET pouch and (d) nylon pouch.

Table 1. Standard for fresh rice noodles evaluation [6, 7].

Characteristics	Evaluation Level	Score
Color	Uniform creamy white	4
	Uniform creamy white – with a little yellowish	3
	Creamy white – with yellowish or some places darkened	2
	Darkened or rather yellowish	1
Texture	Soft – tough – not stuck together	4
	Adequately soft, adequate tough, not stuck together	3
	Little hardened, little tough and little stuck together	2
	Hardened, not tough and much stuck together	1
Flavor	Good flavor without disguised smell	4
	Adequate flavor without disguised smell	3
	Adequate flavor with little disguised smell	2
	Obviously disguised smell	1
Overall acceptance	Very good sensory properties	4
	Good sensory properties	3
	Adequate sensory properties	3
	Bad sensory properties	1

Table 2. Acceptable amounts of microbes in fresh rice noodles.

Types of microbes	Acceptable amounts (log CFU/g)
Total microbes	≤ 7
Yeast & mold	≤ 2
Bacillus species	≤ 2.3

Source: Thai Industrial Standard (TIS 832-2005) [7].

units (CFU) per gram of sample. Acceptable amounts of total microbes, yeast and mold, and bacillus species in the fresh rice noodles are shown in Table 2.

2.5 Determining pH of Fresh Rice Noodles

For the determination of the pH of fresh noodles following AOAC, 1998 [8]; *briefly,* a 50 g sample of each fresh rice noodle was added to 100 ml of distilled water and homogenized with a blender, then all samples were measured for pH in triplicate with a pH meter (Model: F-22 E, HORIBA Ltd., Japan. A pH value indicating the end of shelf life of fresh rice noodles is 4.18.

2.6 Determining Texture Properties of Fresh Rice Noodles

Fresh rice noodles (size 2"×2" with 6 layers) were cooked in boiled distilled water for 45 seconds, washed with 50 ml of distilled water and drained for 15 minutes before the measurement modified from Charutigon *et al.* [9]. A fresh rice noodle firmness test was modified from the AACC (1995) method [10]. The firmness values of cooked fresh rice noodles were measured using an instron universal testing machine equipped with a 50 N load cell and cutting Plexiglas blade. Testing parameters for analysis were set at 2 mm/ min crosshead speed. All samples were measured in triplicate. The results were reported as a maximum force (N) value, extension at maximum force (mm), and total stress value (N/mm).

2.7 Determining Shelf Life of Fresh Rice Noodles

2.7.1 Effect of packaging types on shelf life of fresh rice noodles.

To determine the shelf life of fresh rice noodles, 1 kilogram of fresh rice noodles were packed in HDPE wrap under commercial packing conditions by the local manufacturer (a control sample) as shown in Figure 2 (a). For other samples, 100 g of fresh rice noodles were aseptically packed in HDPE pouch, PET pouch and nylon pouch under vacuum conditions using a vacuum sealer (Model: DZ-280/A, Hualian, Hualian Machinery Co., Ltd., China) as shown in Figure 2 (b), 2 (c) and 2 (d), respectively. All samples were stored at 25°C in the condition room and the sampling times of the noodle samples were collected on days 0, 1, 3, 5, 7, 9, 11, and 13. The sensory evaluation, pH and microbiological properties of all samples were investigated.

2.7.2 Effect of Storage Temperature on Shelf Life of Fresh Rice Noodles.

From the initial shelf life study in part 1, a nylon pouch was the best package of all packaging materials tested to extend the shelf life of fresh rice noodles. So the nylon pouch was chosen as the packaging material used for packing fresh rice noodles in part 2. 100 g of fresh rice noodles were aseptically packaged in nylon pouch under vacuum condition. All samples were stored at 4°C and 25°C and collected at sampling times of: 0, 8, 15, 22, and 29 days. The microbiological and

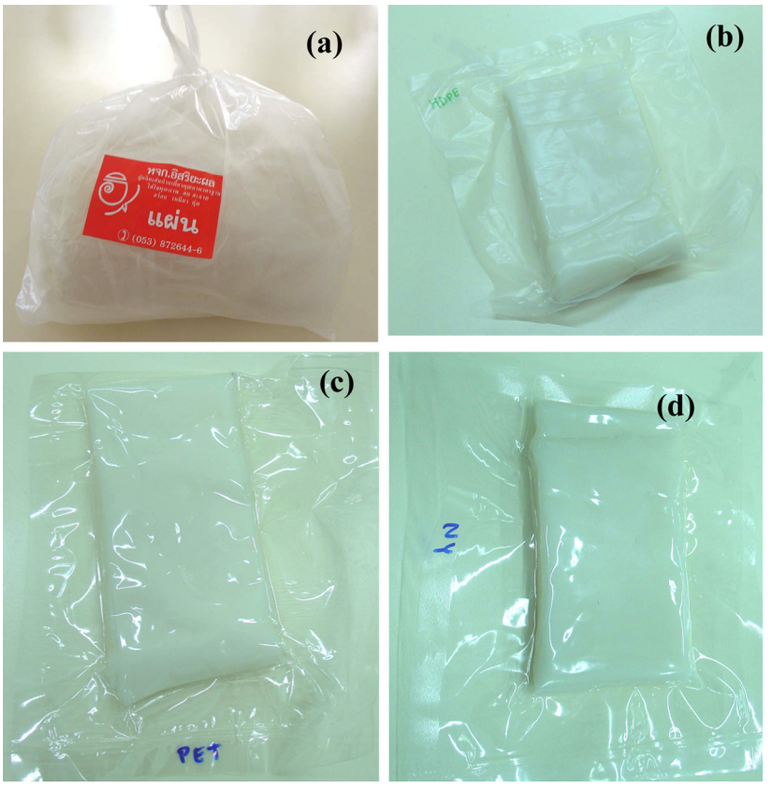

Figure 2. Fresh rice noodles were packed in all packaging materials (a) HDPE wrap, (b) HDPE pouch, (c) PET pouch and (d) nylon pouch.

texture properties of all samples were also investigated.

3. RESULTS AND DISCUSSION

3.1 Effect of Packaging Types on the Shelf Life of Fresh Rice Noodles

3.1.1 Sensory evaluation of fresh rice noodles.

The sensory evaluation of fresh rice noodles packed in four packaging types were evaluated for color, texture, flavor, and overall acceptance as shown in Table 3. The overall acceptances of fresh rice noodles that were packed in both HDPE wrap and HDPE pouch were unacceptable at day 5 because the color of the fresh rice noodles changed as is shown in Figure 3. The high oxygen permeability of the HDPE materials allowed mold to grow in the packaging materials because mold needs oxygen to flourish [11] as is shown in Table 4. On the other hand, fresh rice noodles which were packed in the PET pouch and nylon pouch were unacceptable because of a sour flavor on days 11 and 13, respectively. The sourness is due to acidity from organic acid production such as lactic acid. Thus, the PET pouch and nylon pouch which had low oxygen permeability were linked to natural fermentation in fresh rice noodles under vacumm or low oxygen conditions [12]. Therefore, the quantity of oxygen permeability was an essential factor to the sensory evaluation of fresh rice noodles in all of the packaging types.

Table 3. Sensory properties of fresh rice noodles stored at 25°C.

Day	HDPE wrap				HDPE pouch				PET pouch				nylon pouch			
	color	texture	Flavor	overall acceptance	color	texture	Flavor	overall acceptance	color	texture	Flavor	overall acceptance	color	texture	Flavor	overall acceptance
0	3.8	3.85	3.9	3.85	3.75	3.8	3.8	3.75	3.85	3.9	3.8	3.9	3.8	3.85	3.85	3.85
1	3.7	3.75	3.8	3.9	3.65	3.7	3.85	3.8	3.8	3.75	3.85	3.85	3.75	3.7	3.7	3.75
3	3.8	3.6	3.65	3.8	3.7	3.65	3.75	3.75	3.7	3.25	3.75	3.65	3.7	3.8	3.75	3.75
5	∅	--	--	∅	∅	--	--	∅	3.75	3.15	3.8	3.5	3.8	3.45	3.85	3.75
7	--	--	--	--	--	--	--	--	3.75	3.3	3.7	3.65	3.8	3.5	3.8	3.65
9	--	--	--	--	--	--	--	--	3.8	3.2	3.75	3.7	3.75	3.35	3.8	3.7
11	--	--	--	--	--	--	--	--	3.65	3.35	∅	∅	3.85	3.4	3.7	3.75
13	--	--	--	--	--	--	--	--	--	--	--	--	3.8	3.45	∅	∅

Note: ∅ = Panelist gives 1 point to each characteristic or the average point of each characteristic is less than 2.5

-- = No sensory evaluation

Figure 3: An unacceptable color property of fresh rice noodles.

Table 4. Oxygen and water vapor permeability of all packaging materials.

Packaging types	Oxygen permeability ($g/m^2/day$)	Water vapor permeability ($g/m^2/day$)
HDPE wrap	6,520.80	0.360
HDPE pouch	8,443.15	0.327
PET pouch	174.28	0.750
nylon pouch	91.28	0.090

3.1.2 pH analysis of fresh rice noodles packed in all packaging types stored at 25°C.

In the sensory evaluations, the pH of fresh rice noodles with an unacceptable flavor was 4.18. So the unacceptable pH value used to indicate shelf life of fresh rice noodles in the pH analysis was set at 4.18. The pH values of fresh rice noodles stored at 25°C and storage time (day) are plotted in Figure 4. The pH of fresh rice noodles packed in all packaging types on the first day was 5.41 and continually decreased during the storage period. The result showed that the nylon pouch was the best of all packaging types because it was able to slow down the decrease of pH to an acceptable level (more than 4.18) until day 13. Since the nylon pouch has the lowest oxygen permeability, a low pH and reduced oxygen level are major factors for supporting the growth of lactic acid bacteria (LAB) that produced lactic acid as the major metabolic end product of carbohydrate fermentation. The acidity also changed the texture of the foods due to precipitation of some proteins, and the biochemical conversions involved in growth enhanced the flavor [13]. Thus, the different oxygen permeabilities of the packaging materials affected the growth of LAB and lead to an unacceptable flavor of the fresh rice noodle in a variety of packaging types.

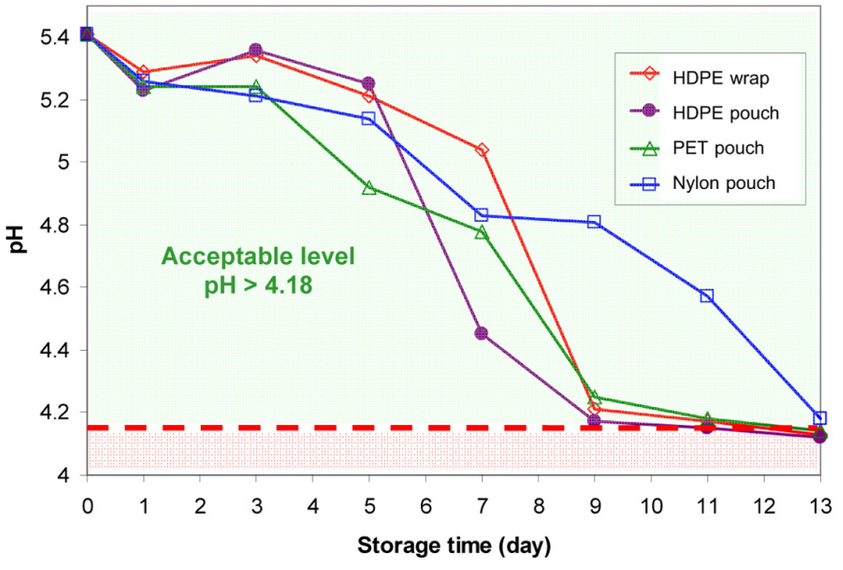

Figure 4. pH of fresh rice noodles stored at 25°C.

3.1.3 Microbiology analysis of fresh rice noodles.

The total amounts of microbes in fresh rice noodles (log CFU/g) stored at 25°C and storage time (day) plotted in Figure 5 show that the initial of total amount of microbes is about 3 logCFU/g in all of the packaging types. An unacceptable level of microorganisms in fresh rice noodle was 7 logCFU/g [7]. The amount of microbes in the nylon pouch increased up to an unacceptable level at a storage time of 13, 11, and 7 days in PET pouch, HDPE pouch and HDPE wrap, respectively. The nylon pouch was the most effective type to control the growth of total microbes followed by PET pouch and both HDPE pouch and HDPE wrap, respectively. Because the nylon pouches have the lowest oxygen permeability of all packaging types, this directly affects the microorganisms which require oxygen to survive. The extension of the shelf life for the vacuum-packaged samples is due to the displacement of the oxygen available for bacterial metabolism in the headspace of the packages, thus slowing the growth by a proportional amount [14]. Similar results were reported by Roth and Clark [15], who investigated the effect of vacuum-packaged on the bacterial flora of fresh beef.

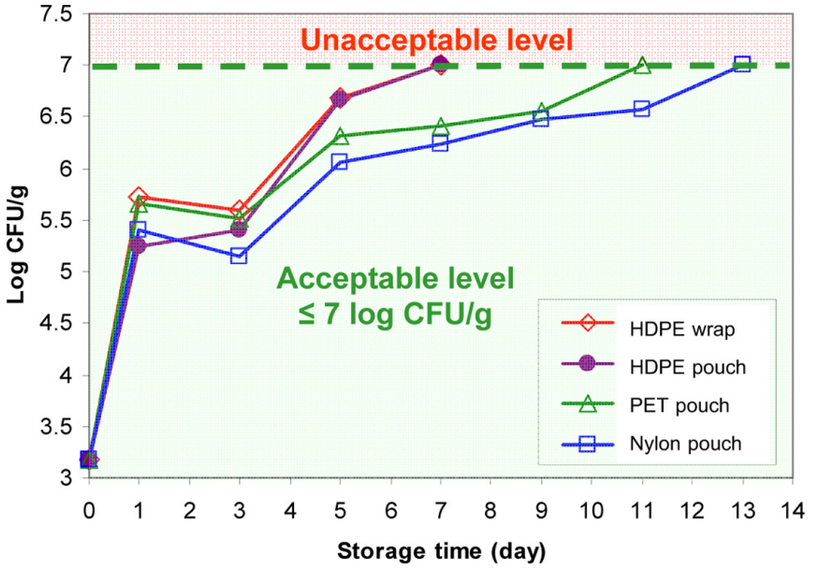

Figure 5. Amounts of total microbes in fresh rice noodles stored at 25°C.

3.2 Effect of Temperature on Shelf Life of Fresh Rice Noodles

3.2.1 Microbiology analysis of fresh rice noodles.

The relationship between amounts of total microbes in fresh rice noodles that were stored at varying temperatures (4°C and 25°C) and storage time (day) are reported in Figure 6. Fresh rice noodles stored at 4°C had longer shelf life than that stored at 25°C. At 4°C, the growth of total microbes in packaged noodles was inhibited and decreased to 2

logCFU/g after 15 days and had a 29 days shelf life. On the other hand, the growth of total microbes in fresh rice noodles that were stored at 2°C increased over time to an unacceptable level at day 13. These results show that the most likely temperatures to be used for refrigerated storage (4°C) was able to prevent the growth of microorganism and extended the shelf life of fresh rice noodles. Furthermore, fresh rice noodles that were stored at 4°C were also investigated for yeast and mold and *Bacillus sp.* during storage for 29 days as is shown in Figure 7. It was found that the growth of the yeast and mold decreased to 2 logCFU/g after storage for 8 days and *Bacillus sp.* was not detected for all storage times. Yeast and mold can grow well at temperatures in the range 25-37°C and *Bacillus sp.* can grow in the temperature range of 10-50°C [16]. O'Brien and Marshall [17]

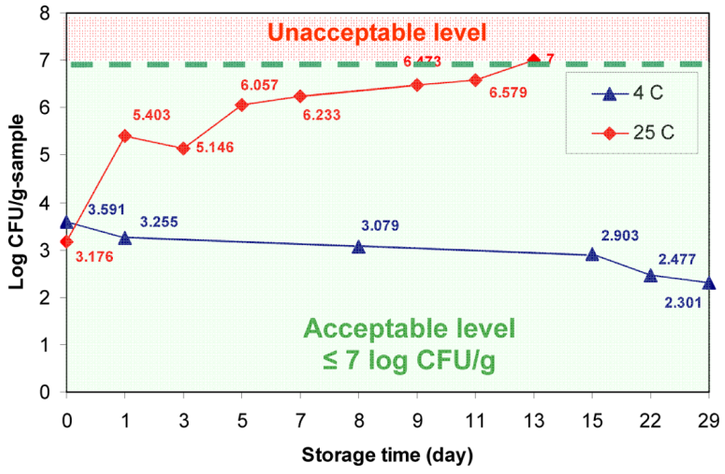

Figure 6. Amounts of total microbes in fresh rice noodles in nylon pouch stored at 4°C and 25°C.

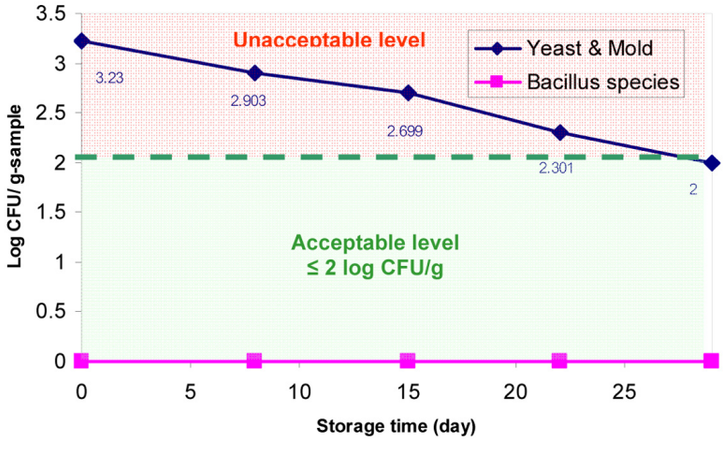

Figure 7. Amounts of yeast & mold and bacillus species in fresh rice noodles in nylon pouch stored at 4°C.

studied the effect of different storage temperatures on the microbiological shelf life of pressurized chicken stored at 25°C which was only 30 hours compared with 40 days at 4°C.

3.2.2 Texture analysis.

Although the 4°C condition could inhibit the growth of total microbes for more than 29 days, the texture of fresh rice noodles deteriorated more quickly as is shown in Table 5. The maximum force and stress of fresh rice noodles stored at 4°C until day 22 were not significantly different from the first day. But the maximum force and stress of fresh rice noodles stored until day 29 were significantly different from the other days. This means that the texture of fresh rice noodles was depreciated by retrogradation, a recrystallization process of starch chains in the gel; providing an undesirable quality [18]. Fresh rice noodles became hardened and sticky. Therefore, in this study, the end of shelf life of fresh noodles stored at 4°C was 29 days.

Table 5. Texture properties of fresh rice noodles stored at 4°C.

Day	Maximum load (N)	Extension at maximum load (mm)	Stress (N/mm)
0	7.68	- 18.61	- 0.273
8	7.55	- 14.39	- 0.263
15	7.41	- 13.78	- 0.263
22	7.60	- 16.67	- 0.270
29	17.12	- 12.03	- 0.607

4. CONCLUSIONS

For studying the effect of packaging types on shelf life of fresh rice noodles packed in vacuum condition at 25°C storage, it was found that nylon pouches proved to be the most efficient to extend the shelf life of fresh rice noodles (13 days) because it had the lowest oxygen permeability of all packaging materials and also longer the shelf life than other packaging materials. The shelf life of fresh rice noodles increased as oxygen permeability of packaging material decreased.

For studying the effect of storage temperatures (4°C and 25°C) on shelf life of fresh rice noodles, it was found that fresh rice noodles have a longer shelf life when stored at 4°C. Low temperatures inhibit the growth of both food spoilage and disease causing microbes and could also slow down the pH decreasing of fresh rice noodles during the storage period. However, fresh rice noodles would lose its texture when stored at low temperature because of retrogradation. The shelf life of fresh rice noodles stored at 4°C reached a maximum at 29 days.

The costs of the packaging materials differed from each other because they had different properties. Therefore, the relationship of the packaging materials properties and its price should be reasonable in order to select the most suitable packaging types for fresh rice noodles.

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