PE4.04 Influence of addition levels of cooked rice on the quality of Thai fermented pork sausages (Nham) during refrigerated storage 20.00

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Abstract—**the objective of this study was to evaluate the influence of addition levels of cooked rice (1, 3, 5, 7 and 10%) on the physico-chemical, microbiological and sensory properties of Thai fermented pork sausages (Nham) during storage at 4ºC for 7 days. In this study, starter cultures that consisted of *Streptococcus thermophilus, Lactobacillus bulgaricus* and *L. rhamnosus* were inoculated during Nham production. The results showed that the pH values of samples decreased significantly with the addition levels of cooked increased. Samples with the addition of 10% cooked rice had significantly lower released water than the other samples. L and b values tended to increase slightly during storage while some fluctuations of a values were observed. Among treatments, samples with addition of 7% cooked rice had significantly lower gel strength, hardness, viscosity and elasticity. Addition levels of cooked rice and storage time did not significantly affect the counts of total viable bacteria and lactic acid bacteria of samples. Nham formulated with a higher portion (i.e. 5%) of cooked rice had higher sensory sourness and overall liking.**

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***Index Terms*—fermented sausage, Nham, quality.**

I. INTRODUCTION

NHAM, which is a traditional Thai fermented pork sausage, is composed of a mixture of pork, sliced pork skin, cooked rice, spices and seasonings. Frequently, the mixture is wrapped with banana leaves or plastic casing and fermented for 3-4 days at ambient temperature, during which it attains a final pH of approximately 4.3-4.7. Quality of Nham depends on many factors such as raw material, microorganisms, processing and fermentation condition and etc. [1]. The fermentable carbohydrates, mainly cooked rice in Nham, are utilized by microorganisms and to produce organic acids, mainly lactic acid, and contributes to a variety of flavors and textures of final products. As frequently consumed without further cooking, it is recommended that pH value of Nham should be lower than 4.6 for the microbial safety concerns [2]. Even though Nham is well accepted and very commonly consumed in Thailand, limited information regarding the quality changes during storage is available [3-5]. Therefore, the objective of this study was to evaluate the effect of various levels of cooked rice (1, 3, 5, 7 and 10%) on the physico-chemical, microbiological and sensory properties of Thai fermented pork sausages during storage at 4ºC for 7 days.

II. MATERIALS AND METHODS

A. Preparation of starter cultures

Pure cultures of *Streptococcus thermophilus, Lactobacillus bulgaricus, Lactobacillus rhamnosus* were obtained from the FIRD, Hsinchu, Taiwan. A 0.015 mL of *S. thermophilus* and *L. rhamnosus* were inoculated in a 7 ml MRS broth and incubated at 37°C for 48 h; *L. bulgaricus* was inoculated in a 7 ml MRS broth and incubated at 37°C for 120 h. Then each of culture was enriched at the same condition and kept at 4°C.

B. Preparation of Nham

Nham was prepared according to the method of Visessanguan *et al.* (2005) and modified. After trimming off visible fat and connective tissue, pork was minced through a 2-mm plate. Pork rind without visible fat was cooked in an autoclave (121ºC) for 3 min and finely shredded. Rice (Thai Jasmine rice) was cooked in autoclave (121ºC) for 1 min. Minced pork (70%) and cooked pork rind (30%) were mixed thoroughly with salt (2%), sucrose (0.4%), MSG (0.2%), polyphosphates (0.2%) and $NaNO_2$ (0.015%) and kept at 4ºC for 24 h. After adding cured meat-rind, starter culture (0.075%), garlic (5%), cooked rice (1, 3, 5, 7 or 10%) and bird chili (2%), the mixtures were mixed thoroughly, stuffed into a plastic casing and sealed tightly prior to incubation at 30ºC for 36 h, stored at 4ºC for 7 days and analyzed accordingly.

C. Proximate composition, pH values and released water

Proximate compositions of samples including moisture, crude fat, crude protein and ash contents, were measured according to the AOAC (1990) methods. Ten gram samples were blended with 90 ml distilled water for 1 min and then the pH of the mixture was measured. The percentage of water released from samples was measured according to the method of Visessanguan *et al.* (2005).

D. Instrumental color measurement

The colors of samples were measured for the L (lightness), a (redness), and b (yellowness) values of samples using a color meter (NR-300, Nippon Denshoku, Japan).

E. Texture properties analyses (TPA)

The texture properties including gel strength, hardness, viscosity and elasticity were measured as the method of Pietrasil and Shand (2003) and modified. TPA parameters were measured using a rheolometer (***SUN SCIENTIFIC Co.,*** LTD. Japan) with the following testing procedure: sample size: $1\times2\times1m^3$, velocity speed 60 mm/min, load distance 13 mm, maximum weight 2 kg and delay time 1 sec.

F. Microbial evaluation

Ten gram samples were aseptically placed in a sterile bag containing 100 ml of sterile water and homogenized with a stomacher for 2 min. Serial dilutions were then made. Plate count agar and MRS agar were used for enumeration of total plate count and lactic acid bacteria count, respectively, and the pour plate method was prepared for enumeration of bacteria and incubated at 37ºC for 48 h.

G. Sensory evaluation

Samples were first tempted to ambient temp (approx. 25ºC), sliced and served to a 12-member panel to assess for appearance, coherence, color, sourness, flavor, juiciness, tenderness and overall liking using a 7-point hedonic scale (1 = dislike extremely, 9 = like extremely).

H. Statistical analysis

Data were analyzed using the general linear model (GLM) of SAS with a 5% level of significance. Means were separated using the Duncan's new multiple range test.

III. RESULTS AND DISCUSSION

No marked differences in the composition of Nham were observed in this study (data not shown). Table 1 showed that the pH values significantly decreased with the addition levels of cooked increased ($P<0.05$). In addition, the pH values of each treatment decreased during storage. At the end of stage at day 7, the pH values of Nham were 4.36-4.74. In fermented meat products, lactic acid bacteria would utilize carbohydrates which are commonly added in the formula of products at the beginning of the processing as a carbon source, produce lactic acid, and finally decrease pH values of products. Samples with addition of 10% cooked rice had significantly lower released water than the other samples ($P<0.05$) while there was no significant difference of released water between the samples with addition of 1 to 7% cooked rice ($P>0.05$). There was no significant difference of released water in each treatment during storage ($P>0.05$).

L and b values tended to increase slightly during storage while some fluctuations of a values were observed probably due to uneven distribution of bird chili in products (Fig 1). In this study, Nham that had more cooked rice added had higher L values which illustrating lighter in color.

Among treatments, samples with addition of 7% cooked rice had significantly lower gel strength, hardness, viscosity and elasticity (Table 2). Texture parameters did not change significantly during storage. In this study, starter cultures that consisted of *Streptococcus thermophilus, Lactobacillus bulgaricus* and *L. rhamnosus* were inoculated during Nham production. The results showed that addition levels of cooked rice and storage time did not significantly affect the counts of total viable bacteria and lactic acid bacteria of samples (Table 3). This result also illustrates that the microbial qualities of Nham were stable during the storage at 4ºC for 7 days.

Table 4 illustrates the scores for overall liking and other sensory characteristics of Nham at day 0 and 7 during storage at 4ºC. Nham formulated with a higher portion (i.e. □5%) of cooked rice had higher sensory sourness and overall liking ($P<0.05$).

IV. CONCLUSION

In this study, Nham, which was inoculated with mixtures of *Streptococcus thermophilus, Lactobacillus bulgaricus, Lactobacillus rhamnosus* and added with various levels of cooked rice, was evaluated. Levels of cooked rice had some influences on the physico-chemical, microbial, and sensory qualities of samples. However, based on the microbial safety concern, cooked rice at level of 7% was recommended to be added during Nham production.

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Table 1. Changes in pH values and released water of Nham with different addition levels of cooked rice during storage at 4ºC

Rice (%)	pH value					Released water (%)				
	Storage time (day)					Storage time (day)				
	0	1	3	5	7	0	1	3	5	7
1	4.93ax	4.89axyz	4.91axy	4.77ayz	4.74az	3.10a	4.03a	3.84a	3.17a	2.48a
3	4.84bx	4.70bxyz	4.77bxy	4.69byz	4.65bz	3.27a	3.41a	3.60a	3.38a	3.44a
5	4.65cx	4.64cxyz	4.64cxy	4.62cyz	4.53cz	3.28a	3.95a	3.31a	3.26a	3.52a
7	4.60dx	4.50dxyz	4.53dxy	4.52dyz	4.48dz	3.15a	2.66a	3.15a	3.55a	3.75a
10	4.51ex	4.38exyz	4.53exy	4.40eyz	4.36ez	2.10b	3.07b	2.63b	2.86b	2.93b

a-e Means within a column for the same test with different superscripts differ significantly ($P<0.05$).
x-z Means within a row for the same test with different superscripts differ significantly ($P<0.05$).

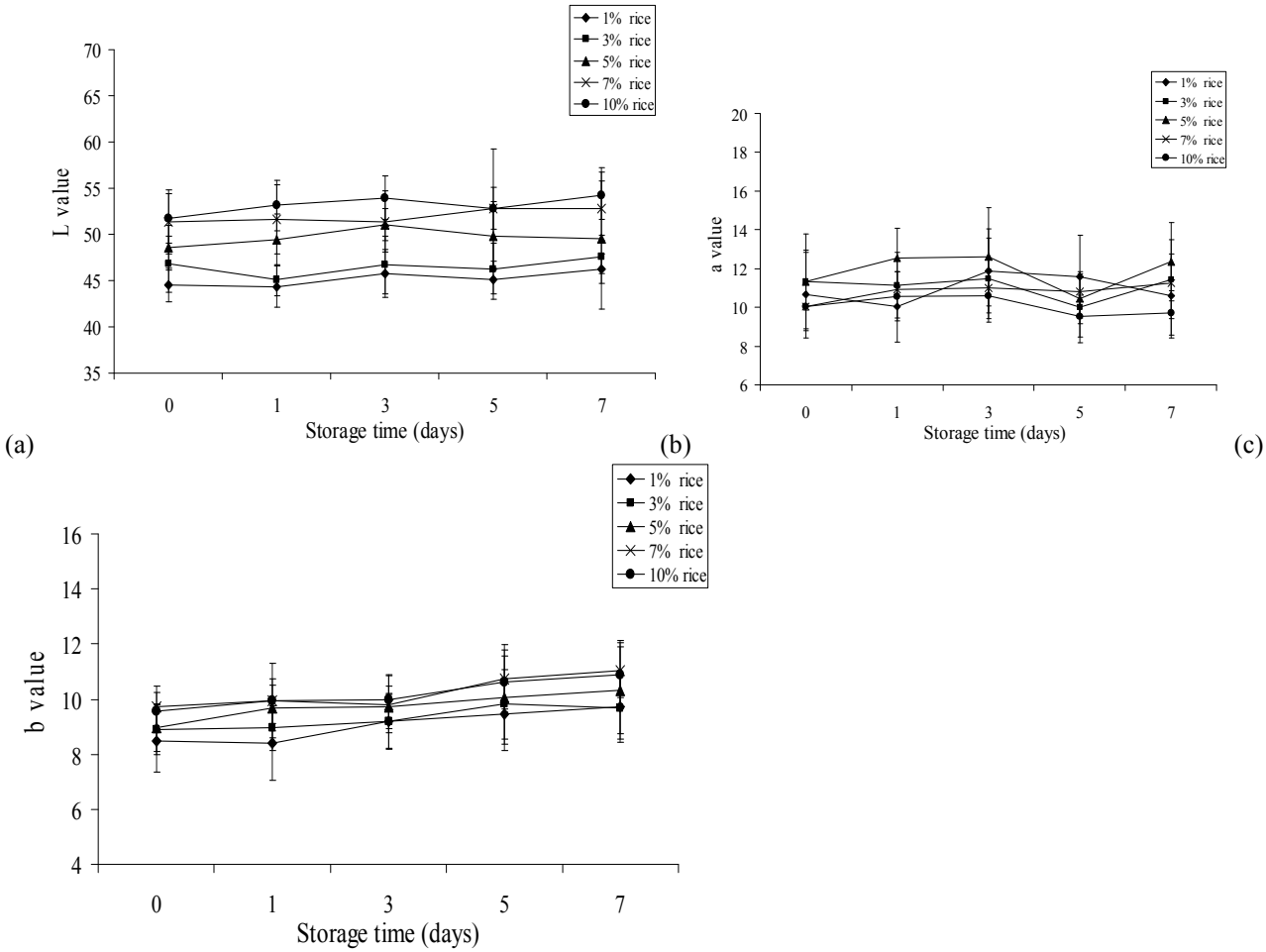

Figure 1. Changes in (a) L (b) a and (C) b values of Nham with different addition levels of cooked rice during storage at 4ºC

Table 2. Changes in textural parameters of Nham with different addition levels of cooked rice during storage at 4ºC

Rice (%)	Gel strength (g) Storage time (day)					Hardness (kg/mm^2) Storage time (day)				
	0	1	3	5	7	0	1	3	5	7
1	598.30b	593.00b	567.00b	709.23a	527.47b	4.56b	4.80a	4.65a	5.58b	4.23b
3	753.13a	679.47a	837.00a	619.57a	703.03a	5.50a	5.58a	5.67a	4.99b	5.48a
5	687.13a	709.07a	670.30a	616.73a	768.47a	5.32a	5.53a	5.34a	4.82b	5.74a
7	532.37b	534.23b	474.77b	575.73b	669.33b	4.24c	4.25b	3.75b	4.48c	4.79b
10	740.77a	686.97a	638.90a	767.83a	655.20b	5.76a	5.56a	4.74a	5.81a	4.78b
Rice (%)	Viscosity (dyn•cm^3) Storage time (day)					Elasticity (dyn) Storage time (day)				
	0	1	3	5	7	0	1	3	5	7
1	4.24a	4.83a	5.36a	4.52a	4.41a	4.80b	4.71b	4.56b	5.47a	4.14c
3	3.92a	5.09a	5.66a	4.27a	4.08a	5.62a	5.47a	5.62a	4.89b	5.25a
5	3.17ab	5.44a	3.77bc	3.94ab	4.94ab	5.21a	5.42a	5.20a	4.73b	5.99a
7	3.05b	4.31b	3.04c	2.70c	2.65c	4.16c	4.00c	3.67c	4.39c	5.27a
10	3.92a	4.26b	4.00b	3.97b	3.25b	5.64a	5.45a	4.91b	5.69a	4.69b

a-c Means within a column for the same test with different superscripts differ significantly ($P<0.05$).

Table 3. Changes in microbial counts of Nham with different addition levels of cooked rice during storage at 4ºC

Rice (%)	Total viable bacteria (log CFU/g) Storage time (day)					Lactic acid bacteria (log CFU/g) Storage time (day)				
	0	1	3	5	7	0	1	3	5	7
1	8.95	8.93	8.92	8.93	8.92	9.00	8.38	8.38	8.46	8.35
3	8.93	8.93	8.93	8.92	8.92	8.60	8.58	8.43	8.41	8.39
5	8.93	8.93	8.92	8.92	8.93	8.45	8.56	8.40	8.38	8.46
7	8.93	8.93	8.93	8.94	8.93	8.51	8.49	8.57	8.62	8.60
10	8.93	8.93	8.93	8.93	8.93	8.42	8.52	8.51	8.46	8.52

a-b Means within a column for the same test with different superscripts differ significantly ($P<0.05$).

Table 4. Sensory evaluation of Nham with different addition levels of cooked rice at the 0 and 7th day during storage at 4ºC

	Rice (%)	Appearance	Color	Coherence	Sourness	Flavor	Juiciness	Tenderness	Overall liking
Day 0	1	4.17	4.33	3.72	3.25c	3.75	4.00	4.39	3.78b
	3	5.11	4.89	4.81	3.64b	4.19	4.33	4.42	4.50a
	5	4.83	4.56	4.97	4.50a	4.39	4.44	4.64	4.78a
	7	4.50	4.42	4.81	4.25a	4.58	4.56	4.58	4.83a
	10	4.69	4.39	5.22	4.75a	4.44	4.31	4.47	4.97a
Day 7	1	5.03	4.94	5.25	3.94c	4.33	4.81	4.67	4.56b
	3	5.39	5.17	5.03	4.67b	4.81	4.67	4.44	4.83a
	5	5.28	5.11	5.08	4.78a	4.97	4.78	4.53	5.19a
	7	5.14	4.97	4.94	5.03a	4.89	4.97	4.86	5.22a
	10	4.64	4.53	4.92	4.94a	4.94	4.61	4.61	5.08a

Based on a seven-point hedonic scale: 7=like extremely; 1=dislike extremely.
a-c Means within a column for the same test with different superscripts differ significantly ($P<0.05$).