An Innovative Local Food Product: Nham Moo-Yor (Thai Fermented Ground Pork Sausage)

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***Abstract*—**The objective of this research was to study and develop a Nham from Moo Yor, a Thai fermented ground pork sausage. The appropriate formulation of Nham Moo-Yor (NMY) was 61.3% Moo Yor (Thai ground pork sausage), 15.3% cooked pork rind, 12.3% cooked rice, 9.2% chopped garlic, 1.2% salt and 0.6% monosodium glutamate. This NMY had yellowish white color in inside the product having L*, a* and b* color value of 52.596, 0.632 and 12.410, respectively, and hardness of 2.719 kg.f, cohesiveness of 0.387, springiness of 0.439 mm and chewiness of 0.453 kg.f.mm. The chemical composition of this product contained 53.87% moisture, 30.97% protein, 5.06% carbohydrate, 4.65% fat, 4.86% ash, 0.60% fiber, 4.40% pH, 0.81% lactic acid and 4.44% salt. Shelf life study showed that fried NMY product (ready to eat NMY) vacuum packed in Nylon/LLDPE laminated bag could be kept at refrigerator temperature (4ºC) for 28 days according to the microbiological standard of ready-to-eat food and traditional fermented food.

***Keywords*—**Thai fermented ground pork sausage, Nham, Moo-Yor, Pork sausage, Fermentation.

I. Introduction

Nham is an indigenous fermented sausage of Thailand and widely consumed in Thailand, especially in the northern part of country. In addition, it is also popularly consumed throughout Southeast Asia [1]. The basic ingredients of Nham are minced pork, cooked pork rind, cooked rice, salt, garlic, sugar and sodium nitrite [2]. Nham fermentation generally takes three of five days and relies mainly on adventitious microorganisms, which are normally found in raw materials [3], [4]. Nham is considered a local authentic in that its flavor and texture vary in accordance with the region in which it is produced. However, one ingredient of Nham, sodium nitrite, is considered as a chemical hazard in this product. It is usually used as an ingredient of Nham to enhance the red color of product. Nevertheless, nitrite can react with secondary and tertiary amines in the pork resulting in carcinogenic nitrosamine [5]. The critical limit of nitrite levels in the Nham mixture is set at 100-200 ppm [6] with the nitrite residue in the product set at not more than 125 ppm [7]. However, Nham generally mixed around 100-125 ppm [3]. Therefore, the reduction and removal of nitrite in fermented sausage of Thailand, in order to avoid the risk of nitrosamine formation and thereby the potential health risks, is utmost importance.

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While, Moo-Yor, Thai steamed pork sausage, is one of the most popular processed meat products in Thailand [8], [9]. It can also made by similar methods but not fermentation. For the manufacture of this product, minced pork, lean pork and seasonings are homogenized until the meat is smooth and steamed. Moo-Yor is absented sodium nitrite leading to quite white in the final product which recognized by consumers and also considered as one important factor determined sensory quality.

Therefore, the objectives of this study were to develop a new local food product: Nham from Moo-Yor namely "Nham Moo-Yor"(NMY) by using Moo-yor, the raw material are not steamed, instead of minced pork in Nham production in order to not add sodium nitrite and to evaluate the physic, chemical, textural, sensory characteristics and shelf life of this product.

II. Experimental Details

1) Preparation of Thai steamed Pork Sausage, Moo-Yor

Moo-Yor was prepared following the method described by [10]. Chilled marinated ground pork (91.69%w/w), was purchased from the fresh market in Tak, Thailand, chopped garlic (6.72%w/w), pepper (0.92%w/w), salt (0.31%w/w), sugar (0.18%w/w) and seasoning (0.18%w/w) were mixed for 5 min until well blended and kept at 4ºC before using.

2) Determination of cooked Rice and Salt Ratios in NMY Production

To study an approximated ratio of NMY for 9 formulas. The variables of cooked rice and salt were study, these are one of variables affecting the quality of Thai fermented sausage [11], [12], by using cooked rice at 10, 15 and 20% and salt at 1, 2 and 3% of Moo-Yor weight. Equal amounts of Moo-Yor and other ingredients were added to each batch of NMY (Table I). The NMY preparation, Moo-Yoo was mixed thoroughly with salt, cooked rice, chopped garlic and monosodium glutamate in a mechanical mixer (Heavy Duty : KitchenAid mixer, USA) at speed level 2 for 2 min. Then, cooked pork rind was added and mixed for 5 min. Each formulas were extruded through the stuffing horn into double layer of polypropylene casing with a diameter of 3.0 cm (approximately 160 g each) and tied at head and tail with rubber band, 3.0 cm in diameter and 12 cm in height. Samples were incubated for 72 hours at 30±1°C. All 9 formulas were randomly sampled at every 0, 24, 48 and 72 hours for pH measurement. Physical and sensory analyses were conducted after 72 hours.

2.1) Chemical and Physical Analyses

Uncooked fermented NMY, which fermented at 0, 24, 48 and 72 hours from 9 formulas, were taken for pH measurement [13] by pH meter (Model PH868-5, China). After 72 hours, moisture content of each formulas was measured using moisture analyzer (Model MAC50/NH, Poland). The color of each formulas was measured in the L*a*b* mode of CIE using a HunterLab (MiniScan EZ-4500L, USA.). The color of there were compensated for by recording the average of three reading taken on the inner surface of the sample without the casing.

TABLE I
NHAM MOO-YOR FORMULATIONS

Ingredients (g)	Formulations, differently in cooked rice and salt								
	1	2	3	4	5	6	7	8	9
Moo-Yor	500	500	500	500	500	500	500	500	500
Cooked pork rind (thickness 2 mm)	125	125	125	125	125	125	125	125	125
Chopped garlic	75	75	75	75	75	75	75	75	75
Cooked rice	50	75	100	50	75	100	50	75	100
Salt	5	5	5	10	10	10	15	15	15
Monosodium glutamate	5	5	5	5	5	5	5	5	5

2.2) Sensory Evaluations

After 72 hours of fermentation, all 9 formulas were fried at 150°C of initial oil temperature for 6 min and cut into 1 cm thick pieces. A balanced incomplete block design (t = 9, k = 3, r = 3, b = 9 and $\lambda = 1$) was used to group samples [14]. Each of the 45 untrained panelists, whom consumed Nham regularly, was randomly assigned one block of three samples from design. Samples were randomly selected and corded with tree-digit random numbers and resented to the panelists a room temperature (25-28°C). Panelists were asked to evaluate for color, odor, taste and overall likeness of NMY using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). The one of appropriate formulation, highest score, was selected to chemical and physical analyses and shelf life of this product.

3) Analyses of the Ready to Eat of Nham Moo-Yor Product

The ready to eat of NMY product (as appropriate formula by selecting from the highest score of sensory evaluation) was fried at 150°C of initial oil temperature for 6 minutes [15] and vacuum packed in Nylon/LLDPE laminated bag. This product was determined color value, using a HunterLab (MiniScan EZ-4500L, USA.) and moisture content, moisture analyzer (Model MAC50/NH, Poland). Textural profile analysis, a texture analyzer (Stable Micro System, TA.XT plus, England) equipped with a cylindrical probe p/100 was applied to determine texture parameters, including hardness, cohesiveness, springiness and chewiness of sample. This sample was cut into cylinder (15 cm height x 1.5 cm diameter) and allowed to equilibrate to room temperature and then compressed twice to 60% of the original height. Force-time deformation curve was obtained with a 50 kg load cell which was applied at a cross-head speed of 5 mm/sec. Proximate composition of sample, including moisture, crude protein, crude fat, ash and fiber contents, was determined [13]. The pH and salt content was measured according to the methods of AOAC [13] as well as total acidity was analyzed as lactic acid.

4) Shelf Life

Ready to eat of NMY was vacuum packed in Nylon/LLDPE laminated bag and stored at 4 ±0.5°C. Sample was taken once a week from 0,7,14 until 28 days for pH measurement and microbiological analysis including total plate counts, yeast and mold, coliform and *Escherichia coli* according to the methods of AOAC [13].

5) Statistical Analyses

Analysis of variance (ANOVA) was performed comparisons between means were analyzed by Duncan's multiple range test [16]

III. Results and Discussion

1) Determination of Cooked Rice and Salt Ratios in NMY Production

1.1) Chemical and Physical Composition

The pH from 9 formulas of uncooked NMY after fermentation at 0, 24, 48 and 72 hours is depicted in Fig. 1. As fermentation time increased, the pH of all formulas decreased continuously until the end of process ($p<0.05$). A sharp decreased in pH lower than 4.6 was found in ratio of rice at 20% and salt 2% (formula number 6) after 48 hours of fermentation ($p<0.05$) which has a high ratio of rice. Correspondingly, reference [17] reported that the increase in cooked rice, which is a carbohydrate source for lactic acid bacteria in the fermentation process, resulted in decreasing fermented time. However, the decrease in pH lower than 4.6, it is recommended that Nham with pH lower than 4.6 is safe for consumption [3], [18], was observed in all formulas after the end of fermentation at 72 hours.

Color values expressed as L*, a* and b* from 9 formulas of uncooked NMY after the end of fermentation at 72 hours is shown in Table II. No marked differences in color values were observed in all formulas ($p>0.05$). The color of all formulas had white-yellow color having L*, a* and b* during 43.86 - 49.87, 1.56 - 2.69 and 10.44 – 12.40, respectively. The L*(lightness) and b*(yellowness) values of all formulas have similar to commercial Nham brand except a*(redness), showed the lower than Nham brand (data not show). The lower redness values in all formulas might be due to these process used Moo-Yor instead of minced pork and not added sodium nitrite in the

production process, imparting a pink color to the product [13]. In moisture content, all formulas were between 57.11 - 61.42%. High level of salt affected to decrease the moisture content of NMY ($p<0.05$).

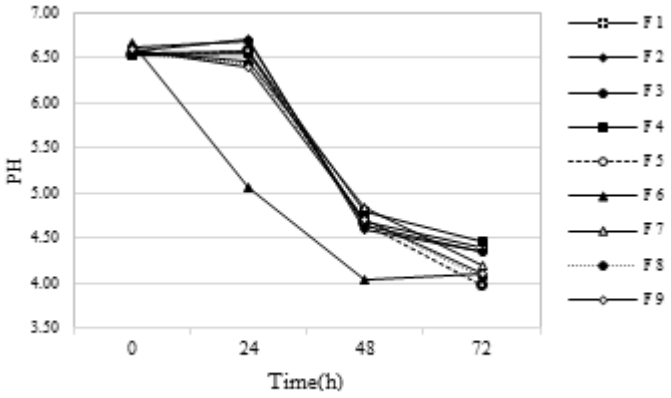

Fig. 1 Changes in pH during fermentation at 30°C.

TABLE II
COLOR VALUE AND MOISTURE CONTENT OF NMY AFTER 72 HOURS OF FERMENTATION.

formulas	Color value and moisture content*			
	L*(ns)	a*(ns)	b*(ns)	Moisture (%)**
1	43.86±1.94	1.89±0.48	10.44±0.56	61.42±2.14[b]
2	49.57±1.73	2.39±0.06	11.57±0.71	59.53±0.91[ab]
3	47.22±1.11	2.19±0.35	11.84±1.39	58.78±1.20[ab]
4	44.06±0.84	2.69±0.25	12.40±0.28	58.52±0.61[ab]
5	47.51±0.93	2.36±0.24	11.72±0.63	57.11±0.59[a]
6	49.87±4.38	1.85±0.25	10.94±0.64	57.74±0.99[a]
7	46.26±1.10	1.56±0.31	12.12±1.28	58.45±1.58[ab]
8	49.68±2.50	2.29±0.40	11.16±0.50	58.94±0.35[ab]
9	46.12±3.78	2.15±0.74	11.37±0.62	59.35±0.79[ab]

* Mean±SD (n=3).
** Different superscripts in the same column indicate the significant differences ($p<0.05$)

1.2) Sensory Evaluations

Color, odor, taste and overall likeness from 9 formulas of cooked NMY after the end of fermentation at 72 hours were scored by 45 untrained panelists as shown in Table III. There was no difference in all attributes among all formulas ($p>0.05$). The results indicated that the cooked rice and salt ratios of NMY product has no impact on sensory properties of all formulas. However, the ratio of rice at 20% and salt 2% (formula number 6) including 61.3% Moo Yor (Thai ground pork sausage), 15.3% cooked pork rind, 12.3% cooked rice, 9.2% chopped garlic, 1.2% salt and 0.6% monosodium glutamate had highest sensory panel score for overall likeness (like very much). Thus, this formula is used to ready to eat of NMY product. Correspondingly of this result, the color likeness of all formulas showed like moderately to like very much (6.60-7.80). It was noted that NMY product is absented sodium nitrite without having any detrimental effect on the color likeness quality of product, leading to reduce the risk of nitrosamine formation of fermented product.

TABLE III
SENSORY EVALUATION OF NMR AFTER 72 HOURS OF FERMENTATION

Formulas	Likeness score*			
	Color(ns)	Oder(ns)	Taste(ns)	Overall(ns)
1	6.87 ± 1.85	7.00 ± 1.36	6.80 ± 2.11	7.07 ± 1.67
2	7.00 ± 1.41	7.13 ± 1.25	6.67 ± 1.40	6.93 ± 0.96
3	7.07 ± 1.62	6.67 ± 1.35	7.07 ± 1.49	7.00 ± 1.20
4	7.00 ± 1.15	7.07 ± 0.88	7.00 ± 1.51	7.20 ± 1.26
5	7.06 ± 1.12	7.27 ± 1.22	7.00 ± 1.36	7.47 ± 0.83
6	7.80 ± 1.08	7.40 ± 1.30	7.13 ± 1.30	7.53 ± 1.41
7	6.60 ± 1.59	6.80 ± 1.74	6.33 ± 2.32	6.53 ± 2.42
8	7.20 ± 0.77	7.20 ± 1.32	6.93 ± 1.33	7.00 ± 1.46
9	7.13 ± 1.13	7.13 ± 1.46	7.60 ± 1.06	7.27 ± 1.33

2) Analyses of Ready to eat of NMR Product

Chemical and physical analyses of ready to eat of NMY product, selected for formula number 6, are shown in the Table IV. Color value of the ready to eat of NMY (cooked NMY) has higher L*and b* values, which had values around 52.59 and 0.63, respectively, than uncooked NMY (Table II). However, the lower a* value of the ready to eat of NMY compared with uncooked was observed. The decreased redness values in this product might be due to protein denaturation during heat [19].

TABLE IV
CHEMICAL AND PHYSICAL COMPOSITIONS OF READY TO EAT OF NMY PRODUCT.

Quality	Contents
Color	
- L*	52.59±3.01
- a*	0.63±0.59
- b*	12.41±1.10
Texture profile	
- Hardness (Kg.f)	2.72±0.28
- Cohesiveness	0.39±0.01
- Springiness (mm)	0.44±0.01
- Chewiness (kgf.mm)	0.45±0.10
Chemical	
- Moisture (%)	53.87±0.22
- Protein (%)	30.96±0.48
- Carbohydrate (%)	5.06±0.15
- Lipid (%)	4.65±0.16
- Ash (%)	4.86±0.08
- Fiber (%)	0.60±0.11
- Total acidity (%)	0.81±0.08
- Salt (%)	4.44±0.15

3) Shelf life

Shelf life of ready to eat of NMY product at 0, 7, 14 and 28 days of refrigerated storages is shown in Table V. After 28

days of storage, there was no difference in pH values ($p>0.05$), which had values around 4.39 – 4.41. Unchanging pH during storage, it was probably due to acid-producing lactic acid bacteria in this product was destroyed during the heating process [15]. Microbial changes of product during storage is shown in Table V. The yeast and mold, Coliform and *E.coli* were not found in all time of storage, while the total plate counts (TPC) of product were found increase during storage (Table V). No marked differences in TPC values were observed in ready to eat of NMY product until day 14 of storage ($p>0.05$). Thereafter, TPC values in this product gradually increased up to day 21 and 28 of storage ($p<0.05$). However, the TPC after 28 days of storage remained in standards of ready to eat foods and traditional fermented food [21]. Therefore, ready to eat of NMY product can be kept at 4°c for 28 days without having any detrimental effect on the microbial quality of product.

TABLE V
CHEMICAL AND MICROBIOLOGICAL QUALITY OF READY TO EAT NMR PRODUCT AFTER 28 DAYS OF STORAGE TIME.

Days	$pH^{(ns)}$	Total plate count (CFU/g)	Yeast and Mold (CFU/g)	Coliform (MPN/g)	*E. coli* (MPN/g)
0	4.40±0.02	$3.1 \times 10^{2\,a}$	nf	nf	nf
7	4.41±0.02	$5.9 \times 10^{2\,a}$	nf	nf	nf
14	4.40±0.01	$1.4 \times 10^{3\,a}$	nf	nf	nf
21	4.39±0.03	$8.6 \times 10^{3\,b}$	nf	nf	nf
28	4.40±0.01	$1.7 \times 10^{4\,c}$	nf	nf	nf

IV. Conclusions

Nham produced from Moo-Yor contained with 61.3% Moo Yor, 15.3% cooked pork rind, 12.3% cooked rice, 9.2% chopped garlic, 1.2% salt and 0.6% monosodium glutamate had highest sensory panel score in like very much which absented sodium nitrite without having any detrimental effect on the color likeness quality. The ready to eat NMR product also kept at 4°C for 28 days according to the microbiological standards of ready to eat foods and traditional fermented food. Therefore, NMY can be used as a new product development for food fermentation to lowering the risk of health problem from nitrite levels in cured meat product.

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