Using Potassium Sorbate and Vacuum Packaging to Extend Shelf Life of Thai Fermented Pork Sausages (Sai Krok Prew)

Panthitra Phromraksa[1], Pairote Wiriyacharee[2*], Lakkana Rujanakraikarn[3] and Pattawara Pathomrungsiyungkul[4]

[1]*Department of Food Science and Technology, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50200, Thailand*

[2]*Department of Product Development Technology, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50200, Thailand*

[3]*Food Technology Program, School of Agro-Industry, Mae Fah Luang University, Chiang Rai 57100, Thailand*

[4]*Department of Food Engineering, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai 50200, Thailand*

**Corresponding author. E-mail: deanagro@chiangmai.ac.th*

ABSTRACT

Effect of potassium sorbate concentration (2–10%) and dipping time (1–2 min) on residual sorbate contents in Sai Krok Prew was studied. It was found that the amount of residual sorbate in sausages varied, depending only on potassium sorbate concentration and their relation followed a quadratic equation. The equation showed that sorbate residues in samples increased with potassium sorbate concentration and residual sorbate ~ 945 ppm as sorbic acid was found in Sai Krok Prew, dipped in 3.5% potassium sorbate solution for 1 min. Four treatments of Sai Krok Prew, A (sorbate-untreated/air-pack), V (sorbate-untreated/vacuum-pack), PA (sorbate-treated/air-pack) and PV (sorbate-treated/vacuum-pack) were assessed every 2 days during storage at 30°C. Fermented sausages were analyzed for mold counts, residual sorbate, total acidity, pH, Hunter color L, a, b values, shear force and sensory test in terms of color before cooking, color after cooking, saltiness, sourness, sour odor, stickiness, juiciness and total acceptability. Constant, increase and decrease trends of those qualities during Sai Krok Prew storage were found in present study. Shelf life of products were primarily determined by mold populations, sourness and overall acceptability. Ability of treatments to inhibit mold growth was PV>PA>V whereas A treatment had an inability. However, efficiency of treatments to extend shelf life of Sai Krok Prew was PA>PV>V with shelf life of 10, 8 and 6 days respectively. Test panels rejected PV treatment stored for 10 days because it was too sour.

Key words: Fermented sausages, Shelf life, Potassium sorbate, Vacuum Packaging

INTRODUCTION

Sai Krok Prew or Sai Krok E Sarn, a kind of Thai fermented sausages, are made from pork, pork lard, cooked rice and seasoning, stuffed into pork casing or other edible casings and then fermented until becoming sour, and cooked before eating (Thai Industrial Standards Institute, 1994). Mostly they are produced by home industry or small factories, and sold in both uncooked item and cooked pieces ready to eat. The expansion of Sai Krok Prew into market area is limited by short shelf life of product due to mold growth. At room temperature, uncooked Sai Krok Prew can be kept only for a few days. If their shelf life can be extended to about seven days or more, they will give an advantage to producer. Larger-scaled manufacture will be launched because of the extension of marketing. Potassium sorbate is particularly effective in inhibiting mold growth and has been extensively utilized for this purpose in certain foods, including sausages (Sofos and Busta, 1993). There was a recommendation on dipping of fermented sausages in a 10–20% potassium sorbate solution to prevent undesirable and possibly toxigenic mold growth (Robach and Sofos, 1982). However, according to the regulation set by the Ministry of Public Health No.84, the maximum usage of potassium sorbate in food is 1,000 ppm as sorbic acid (Ministry of Public Health, 1984). Applying potassium sorbate with sodium nitrite and sodium nitrate inhibited the growth of molds and yeasts in sucuk (a traditional fermented dry sausage of Turkey) and higher reduction of these microorganisms were observed in sausages added with high levels of these additives than low levels (Bozkurt and Erkmen, 2002). Potassium sorbate increased the firmness of poultry frankfurters but did not influence their flavor (Chambers et al., 1981). The use of vacuum packaging for meat product has recently increased in order to extend the shelf life and widen the present market. Processed meat products can benefit from vacuum packaging, which avoids surface drying, mold growth and greatly slows down the oxidation of fat and pigments (Rossi, 1993). There were some researches on the use of potassium sorbate in combination with vacuum packaging to preserve smoked fish (Geminder, 1959), ham (Kemp et al., 1981) and bacon (Amundson et al., 1982). This research, therefore, was planned to determine the effect of concentration of potassium sorbate solution and dipping time on residual sorbate and to extend shelf life of Sai Krok Prew by using potassium sorbate and vacuum packaging.

MATERIALS AND METHODS

Materials

Minced pork (lean meat), minced pork lard, cooked sticky rice, garlic and white pepper were purchased from a local market (Chiang Mai, Thailand). Cooked sticky rice was rinsed through water (1 L drinking water per 150 g cooked sticky rice) to remove the sticky layer. Garlic was peeled and then ground in a universal food processor (Model CombiMax 750: Braun, Germany) for 1 min. Sodium nitrate, sodium nitrite and potassium sorbate (food grade) were bought from a local chemical shop. Three starter cultures were used in sausages preparation. *Lactobacillus plantarum* in Lactobacilli MRS broth (Difco Laboratories, USA) was incubated in an incubator (Model D-6450 Hanau : Heraeus, Germany) at 30°C for 24 hr. This procedure was also used for *Pediococcus cerevisiae*. *Micrococcus varians* was maintained in brain heart infusion broth (BHI, Difco Laboratories, USA) at 30°C for 48 hr inside an incubator.

Sausage preparation

Minced pork, minced pork lard and cooked sticky rice (46.84:23.60:29.56) were called “meat system”. Other ingredients were: ground garlic (10), white pepper (1.00), coriander seed (1.00), sodium nitrate (0.05), sodium nitrite (0.0125), sucrose (1.60) and salt (2.07) (weight % based on meat system). Three starter cultures were added at 6 Log cfu/g meat system for each bacteria.

Sausage preparation was: mixing minced pork, salt, sodium nitrate and sodium nitrite in a mechanical mixer (Model 5K5SS: KitchenAid, USA) for 1 min. Then ground garlic, white pepper, coriander seed and sugar were added and mixed for 1 min. Cooked sticky rice was mixed additionally for 2 min, then minced pork lard was added and mixed for 2 min. Finally, starter cultures were poured into the mixture and mixed for 1 min. The mixture was then stuffed into 2.3-cm diameter collagen casings (Nippi Incorporated, Japan) and tied with thread. Each piece of fresh sausages was of ~2.5 cm in length. Fresh sausages were fermented at 30°C for 24 hr in an incubator. In sorbate-treated treatment, fresh sausages were dipped in potassium sorbate solution before fermentation.

Packaging

Sausages without packaging were studied in Experiment 1 whereas sausages in both air pack and vacuum pack were studied in Experiment 2. In Experiment 2, sorbate- treated and sorbate-untreated fermented sausages were packed by a packaging machine (Model VM 2010: Audionvac, U.S.A). Fermented sausages, approximate total weight 400 g, were packed to a bag which was a laminate of Nylon/LLDPE (Prepac Thailand Ltd., Thailand). In those treatments which were air packs, the bag was heat-sealed without evacuation. In those vacuum packs, the bag was evacuated before heat-sealing, resulting in the film to be in firm contact with the sausages. All packs were stored in a 30°C incubator where samples were randomly taken for analysis every 2 days during storage.

Experimental design and statistical analysis

This research was composed of two continuous experiments as described below.

Experiment 1: Effect of potassium sorbate concentration and dipping time on residual sorbate content.

The 2^2 factorial experiment in central composite design used in this study is presented in Table 1. Eleven treatments were analyzed for the residual content of sorbate. The values of two independent factors (potassium sorbate concentration and dipping time) and a dependent variable (residual contents of sorbate) were computed by using SPSS 10.0 to form the stepwise multiple regression equation which was coded equation. Then Mathcad 7 professional program was used to transform the coded equation into the decoded equation needed for determining the suitable concentration of potassium sorbate solution and dipping time which continuously applied in Experiment 2.

Table 1. Treatments planned by a 2^2 factorial experiment in central composite design.

Code*	(1)	a	b	ab	-αa	+αa	-αb	+αb	cp1	cp2	cp3
Potassium sorbate concentration (%)	3.17	8.83	3.17	8.83	2.00	10.00	6.00	6.00	6.00	6.00	6.00
Dipping time (min)	1.15	1.15	1.85	1.85	1.50	1.50	1.00	2.00	1.50	1.50	1.50

*a = potassium sorbate concentration; b = dipping time; +α = highest level; -α = lowest level; (1) = control; and cp_1, cp_2, and cp_3 = center point.

Experiment 2: Using potassium sorbate and vacuum packaging to extend shelf life of Sai Krok Prew at 30°C.

Duplicate of four treatments as shown in Table 2 were prepared. Samples were randomly taken for analysis on mold population, sorbate content, total acidity, pH, Hunter color L, a, b values, shear force and sensory evaluation. Data were analyzed by Analysis of Variance (ANOVA) and comparisons between means were performed by Duncanûs multiple range test.

Table 2. Four treatments of sausages in Experiment 2.

Treatment	Potassium sorbate*	Packaging
A	Nil	Air
V	Nil	Vacuum
PA	Dip	Air
PV	Dip	Vacuum

*Concentration of potassium sorbate solution and dipping time from conclusion of Experiment 1.

Mold population analysis

The enumeration of mold was expressed as cfu/g (AOAC, 2000).

Sorbate content, total acidity, pH, Hunter color and shear force analysis

Sorbate contents as ppm sorbic acid and total acidity as lactic acid were analyzed (AOAC, 2000). pH values were measured (AOAC, 2000) by pH meter (Model HI 9321: Hanna, Portugal). Hunter color L, a, b values were measured with chroma meter (Model CR-310 : Minolta Camera Co.Ltd., Japan). Shear force values were analyzed by Universal Testing Machine (Model 5565 : Instron, U.S.A.).

Sensory analysis

Uncooked fermented sausages were determined for color by test panels while cooked fermented sausages were evaluated on color, saltiness, sourness, sour flavor, stickiness and juiciness. All attributes were evaluated together in terms of overall acceptability. Cooking sausages was done in a cooker at 180–240°C for 30 min. The sensory panels were comprised of 10 trained graduate students. The ideal ratio profile technique (Wiriyacharee, 2003) was used for the test. The ratio 1.00 indicated that the product had attributes as good as the ideal product. The more the value was near 1.00, the more optimum quality of product was. The ratio < 1.00 or >1.00 suggested that sample had attributes lower or higher than of the ideal product, respectively. When the ratio of overall acceptability was ≤0.5, product was rejected.

RESULTS AND DISCUSSION

Experiment 1: Effect of potassium sorbate concentration and dipping time on residual sorbate content.

Levels of residual sorbate as sorbic acid in all treatments ranged from 471.50+2.57–1,367.23+0.86 ppm (Table 3). Decoded equation (Eq. 1) presented that only potassium sorbate concentration affected levels of residual sorbate whereas dipping time did not show influence. Additionally, it indicated that the higher the concentration, the higher the residual sorbate was found. It was found from Eq.1 that dipping fresh sausages in 3.5% potassium sorbate solution for 1–2 min resulted in the residue of 945 ppm sorbic acid in Sai Krok Prew. This residual amount did not exceed the limit of Ministry of Public Health (1984). There were some successful reports to preserve meat products by dipping in potassium sorbate solution for 1 min such as ham slices (Baldock et al., 1979), rib eye steaks (Greer, 1982), chicken thighs (Gray et al., 1984) and morwong fillets (Statham et al., 1985). Thus, 1 min should be a suitable dipping time in order to reduce processing time in our study. In conclusion, the optimum procedure to use this preservative would be dipping fresh sausages in 3.5% potassium sorbate solution for 1 min.

$$S = 561.54125 + 128.80825\ P - 5.46643\ P^2 \qquad (1)$$

Where P = concentration of potassium sorbate solution (%) and S = content of residual sorbate (ppm as sorbic acid).

Table 3. Residual sorbate content as sorbic acid (Mean±S.D.) in Sai Krok Prew varying potassium sorbate concentration and dipping time.

Code*	Potassium sorbate concentration (%)	Dipping time (min)	Residual sorbic content (ppm as sorbic acid)
(1)	3.17	1.15	902.41±1.55
a	8.83	1.15	1,279.61±1.13
b	3.17	1.85	906.62±0.74
ab	8.83	1.85	1,285.30±0.74
$-\alpha a$	2.00	1.50	471.50±2.57
$+\alpha a$	10.00	1.50	1,367.23±0.86
$-\alpha b$	6.00	1.00	1,111.80±1.55
$+\alpha b$	6.00	2.00	1,123.68±1.13
cp_1	6.00	1.50	1,122.69±0.74
cp_2	6.00	1.50	1,126.40±1.96
cp_3	6.00	1.50	1,116.75±0.74

*a = potassium sorbate concentration; b = dipping time; $+\alpha$ = highest level; $-\alpha$ = lowest level; (1) = control; and cp_1, cp_2, and cp_3 = center point.

Experiment 2 : Using potassium sorbate and vacuum packaging to extend shelf life of Sai Krok Prew at 30°C.

Changes of mold populations in Sai Krok Prew during storage at 30°C

Mold populations in all treatments during storage are presented in Table 4. Initial mold counts in all treatments were <30 cfu/g, agreeing with TSI 1266–1994 standard which indicates that mold population in Sai Krok E Sarn must not exceed 100 cfu/g(Thai Industrial Standards Institute, 1994). Rapid increase in mold numbers occurred in A treatment, reaching around 120–150 cfu/g after 2 days. This agrees with the fact that molds are aerobic microorganism. In V treatment, mold populations were stable at <30 cfu/g for 6 days and then increased rapidly to 580–640 cfu/g 2 days later. This indicated that vacuum packaging inhibited but did not prohibit mold growth during Sai Krok Prew storage. Mold increase was probably due to the fact that they consumed residual oxygen in vacuum packaging. Treatment PA gave a lag period of 10 days, followed by a rise to around 440–510 cfu/g after 12 days storage. Baldock et al., (1979) reported that after 30 days of storage in a room held at 21.1˚C, molds on whole ham untreated with potassium sorbate were too numerous to count while 10% potassium sorbate-treated samples showed mold counts of 16–240 cfu/cm^2. Proposed mechanisms of inhibition of microbial growth by sorbate include alterations in the morphology, integrity, inhibition of transport function of cell membranes and inhibition of metabolic activity (Sofos and Busta, 1993). Our study indicated that using potassium sorbate alone retarded but did not stop mold growth. Combination of potassium sorbate and vacuum packaging, i.e., PV treatment, was the most efficient method to control mold growth because its mold populations were lower than mold standard through 16 days storage. The antimicrobial activity of sorbate is usually enhanced under vacuum storage condition (Sofos and Busta, 1993). Thus, A, V and PA treatment agreed with TSI 1266–1994 standard only for 0, 6 and 10 days of storage respectively, whereas at least 16 days for PV treatment.

Changes in residual sorbate levels in Sai Krok Prew during storage at 30°C

Table 4 shows changes of residual sorbate contents during storage. The initial levels of residual sorbate in PA and PV treatments were very close to 945 ppm sorbic acid. During storage, levels of residual sorbate in both treatments decreased significantly ($p \leq 0.05$). This might be due to potassium sorbate acting as fungistatic agent in Sai Krok Prew. Under appropriate conditions, sorbate can be metabolized as fatty acid through β-oxidation by certain microorganisms (Sofos and Busta, 1993). After 12 days, sorbate dropped by 90% (947.32 to 95.34) and 79% (946.12 to 197.34) for PA and PV treatment respectively. Reduction of residual sorbate in PV treatment was slower than in PA treatment. Little oxygen in vacuum pack might reduce the rate of oxidation. Residual sorbate concentration in ham slices decreased by ~50% (583.5 to 250.0) after 60 days storage at 22±5°C (Baldock et al., 1979) as well as it reduced by ~35% (804.9 to 519.4) in the intermediate-moisture fish after storage for 14 days at 35°C (Pathomrungsiyungkul, 2000). Thus, sorbate reductions in our study were very rapid. Under certain conditions some lactic acid-producing bacteria strains can degrade sorbate (Sofos and Busta, 1993). Lactic acid-producing bacteria are dominant microorganism in fermented sausages, therefore quick reduction of sorbate in our study was probably due to metabolism by this culture.

Changes in total acidity and pH in Sai Krok Prew during storage at 30°C

Changes in total acidity and pH in Sai Krok Prew during storage at 30°C are shown in Table 4. Increment in total acidity and reduction in pH were found significantly ($p \leq 0.05$) in all treatments during storage. These results confirm the fact that *L. plantarum* and *P. cerevisiae* have a fermentative metabolism which produce lactic acid and accumulate in the products. Additionally, both trends in PA and PV treatment indicated that both starter cultures survived and produced lactic acid in Sai Krok Prew dipped in 3.5% potassium sorbate solution for 1 min. The resistance of the lactic-acid bacteria to sorbate permits the use of potassium sorbate as a fungistat in products that undergo lactic fermentations (Jay, 1992). Changes of pH in Sai Krok Prew during storage were opposite to those in sucuk, using starter cultures and fermented for 15 days as reported by Bozkurt and Erkmen (2002). They found that pH of sucuk increased ($p<0.05$) during 45 days of storage at 20°C due to decomposition of acids. Total acidity contents of PV treatment were higher than of PA treatment during storage (except day 2 and 6), while pH values in PV treatment were lower than in PA treatment since day 2 to day 12 of storage. These changes agree with the fact that both starter cultures prefer anaerobic condition to produce lactic acid.

Table 4. Changes in mold population, residual sorbate level, total acidity and pH of Sai Krok Prew during storage at 30°C.

Treatment*	**Storage time (day)**						
	0	**2**	**4**	**6**	**8**	**10**	**12**
				Mold population (cfu/g)**			
A	<30	120–150	-	-	-	-	-
V	<30	<30	<30	<30	580-640	-	-
PA	<30	<30	<30	<30	<30	<30	440-510
PV	<30	<30	<30	<30	<30	<30	<30
				Residual sorbate level (ppm sorbic acid)			
PA	947.32±0.43^{g}	659.15±0.45^{f}	529.61±8.45^{e}	466.66+0.43^{d}	311.75+1.21^{c}	147.36+0.43^{b}	95.34+0.45^{a}
PV	946.12±1.04^{g}	731.13±0.45^{f}	561.26±1.84^{e}	522.33+6.51^{d}	458.00+0.44^{c}	385.38+0.44^{b}	197.34+0.47^{a}
				Total acidity (% as lactic acid)			
A	0.77±0.01^{a}	1.20±0.07^{b}	-	-	-	-	-
V	0.77±0.03^{a}	1.27±0.02^{b}	1.42±0.05^{c}	1.92±0.05^{d}	1.92±0.05^{d}	-	-
PA	0.77±0.02^{a}	1.24±0.02^{b}	1.52±0.02^{c}	1.85±0.02^{d}	1.74±0.04^{e}	1.98+0.05^{f}	2.45+0.05^{g}
PV	0.78±0.02^{a}	1.19±0.05^{b}	1.68±0.05^{c}	1.70±0.02^{c}	1.81±0.02^{d}	2.14+0.02^{e}	2.49+0.07^{f}
				pH			
A	4.24±0.02^{b}	3.97±0.01^{a}	-	-	-	-	-
V	4.23±0.02^{c}	3.97±0.02^{b}	3.96±0.01^{b}	3.89±0.01^{a}	3.88+0.01^{a}	-	-
PA	4.21±0.01^{f}	3.98±0.01^{e}	3.97±0.03^{e}	3.93±0.01^{d}	3.83+0.02^{c}	3.74+0.01^{b}	3.60+0.02^{a}
PV	4.22±0.01^{g}	3.96±0.02^{f}	3.90±0.01^{e}	3.84±0.01^{d}	3.76+0.01^{c}	3.72+0.01^{b}	3.58+0.02^{a}

* A = air packaging of sausage without sorbate; V = vacuum packaging of sausage without sorbate; PA = potassium sorbate treated and air packaging; PV = potassium sorbate treated and vacuum packaging.

** Mold populations in PV treatment were less than 100 cfu/g until day 16 (data not shown).

$^{a-b}$ Means+S.D., except for mold population, within the same row followed by different superscripts are different ($p<0.05$).

- No detection.

Changes in Hunter color of Sai Krok Prew during storage at 30°C

Changes in Hunter color L, a, b values of fermented sausages during storage are given in Table 5. Hunter L values (lightness) of all treatments decreased significantly ($p\leq0.05$) with increasing storage time. For A treatment, initial Hunter a value (redness) was not different ($p>0.05$) from day 2. For V and PA treatment, Hunter a values were quite constant during storage. Higher in Hunter a values significantly ($p\leq0.05$) during storage were found in PV treatment. Again, Hunter b values (yellowness) of A treatment were constant ($p>0.05$) during 2 days storage. For V treatment, Hunter b values did not change ($p>0.05$) during the first 4 days but increased significantly ($p\leq0.05$) after 6 days storage and then became constant ($p>0.05$) again at the end of storage. Significantly ($p\leq0.05$) higher in Hunter b values during storage were found in PA and PV treatment.

Changes in shear force of Sai Krok Prew during storage at 30°C

Changes in shear force or hardness of Sai Krok Prew during storage are presented in Table 5. There was no significant difference ($p>0.05$) of shear force during 2 days storage for A treatment. In V, PA and PV treatment, there were significant reduction trends ($p\leq0.05$) in shear force during storage. It was probably because cooked sticky rice in Sai Krok Prew was changed to reducing sugar and continuously fermented to lactic acid by lactic-acid bacteria. Additionally, ground pork might have been decomposed partially by some cultures. Many microorganisms can metabolize meat proteins, peptides and amino acids through intracellular or extracellular proteolytic enzymes (Bacus, 1984).

Table 5. Changes in Hunter color L, a, b values and shear force of Sai Krok Prew during storage at 30°C.

Treatment*	Storage time (day)						
	0	2	4	6	8	10	12
				Hunter L			
A	74.37±0.30^{b}	72.07±0.47^{a}	-	-	-	-	-
V	74.30±0.32^{d}	70.47±0.47^{c}	68.73±0.50^{b}	69.31±0.24^{b}	68.06±0.14^{a}	-	-
PA	75.22±0.25^{e}	72.77±0.43^{d}	72.64±0.21^{d}	71.71±0.05^{c}	71.30±0.28^{bc}	71.00±0.40^{b}	68.36±0.27^{a}
PV	75.55±0.40^{e}	72.62±0.21^{d}	72.15±0.15^{d}	70.91±0.11^{c}	70.63±0.44^{bc}	70.15±0.43^{b}	67.85±0.34^{a}
				Hunter a			
A	10.41±0.40	10.26±0.18	-	-	-	-	-
V	10.48±0.47^{b}	10.21±0.22^{ab}	9.78±0.12^{a}	9.82±0.20^{a}	10.65±0.13^{b}	-	-
PA	9.98±0.33b^{c}	9.62±0.27^{ab}	9.76±0.14^{abc}	9.50±0.41^{a}	9.86±0.02^{abc}	10.16±0.22^{c}	10.21±0.27^{c}
PV	9.97±0.33^{a}	10.32±0.15^{bc}	10.01±0.12^{ab}	9.99±0.10^{b}	10.24±0.19^{abc}	10.54±0.17^{cd}	10.74±0.16^{d}
				Hunter b			
A	17.63±0.33	18.12±0.14	-	-	-	-	-
V	17.67±0.40^{a}	17.79±0.17^{a}	17.47±0.18^{a}	18.58±0.21^{b}	18.42±0.06^{b}	-	-
PA	17.93±0.46^{b}	17.35±0.30^{a}	17.96±0.10^{b}	18.92±0.12^{d}	18.68±0.22^{cd}	18.46±0.19^{c}	18.44±0.03^{c}
PV	17.91±0.49^{abc}	17.84±0.48^{ab}	17.72±0.39^{a}	18.61±0.22^{d}	18.38±0.08^{bcd}	18.52±0.37^{cd}	18.75±0.23^{d}
				Shear force (N)			
A	20.10±0.26	19.46±0.36	-	-	-	-	-
V	20.08±0.11^{d}	19.13±0.33^{c}	12.06±0.34^{b}	11.84±0.20^{b}	11.19±0.45^{a}	-	-
PA	20.35±0.27^{b}	19.77±0.45^{b}	11.78±0.44^{c}	10.58±0.11^{b}	10.19±0.19^{b}	9.27±0.21^{a}	8.78±0.47^{a}
PV	20.69±0.40^{f}	19.91±0.24^{e}	11.79±0.23^{d}	11.50±0.40^{d}	10.15±0.29^{c}	9.45±0.37^{b}	8.46±0.13^{a}

* A = air packaging of sausage without sorbate; V = vacuum packaging of sausage without sorbate; PA = potassium sorbate treated and air packaging; PV = potassium sorbate treated and vacuum packaging.

$^{a-b}$ Means±S.D. within the same row followed by different superscripts are different ($p\leq0.05$).

\- No detection.

Changes in sensory characteristics of Sai Krok Prew during storage at 30°C

Changes in sensory characteristics of Sai Krok Prew during storage at 30°C are presented in Table 6. As described before that mold populations in A, V and PA treatment after 2, 8 and 12 days storage respectively were higher than allowance of TSI 1266–1994, therefore Sai Krok Prew of those treatments were not evaluated on sensory for safety reason of test panels. In case of PV treatment, its mold counts agreed with this standard through 16 days. However, score of total acceptability of samples stored for 10 days was 0.50±0.21 (Table 6), indicating that test panels rejected this treatment. Therefore, only PV treatment was evaluated on sensory until day 10.

Though colorimeter could detect some changes in color in V treatment as mentioned above, panelists could not find significant difference ($p>0.05$) in color of uncooked sausages during storage. For PA treatment, initial ratio of uncooked sausages color was not different ($p>0.05$) with this ratio on day 2, 6 and 10 but significantly higher ($p\leq0.05$) than those on day 4 and 8. For PV treatment, there were no significant differences ($p>0.05$) of uncooked sausage color on day 6 and 10 from day 0, whereas those ratios on other days were lower significantly ($p\leq0.05$) than on day 0.

In case of color after cooking, there were no changes of score ($p>0.05$) in V, PA and PV treatment during storage though there were certain differences of uncooked color in PA and PV treatment. This indicated that test panels could not differentiate color after cooking of sausages prepared by method in this research. Moreover, no significant change in stickiness of V, PA and PV treatment was found during storage.

There were no significant changes ($p>0.05$) in saltiness of V and PA treatment during storage. For PV treatment, saltiness was constant ($p>0.05$) during the first 8 days of storage and then significantly decreased ($p\leq0.05$) at the final day.

Panelists found that sourness of Sai Kork Prew of V, PA and PV treatment increased significantly ($p\leq0.05$) with increasing storage time. This trend agreed with increasing in total acidity and reducing in pH. For PV treatment stored for 10 days, with total acidity of $2.14\pm0.02\%$ and pH of 3.72 ± 0.01 (Table 4), its sourness ratio was 1.30 ± 0.15 with additional judgement of panelists to reject this sample because it was too sour. Excessive sourness of fermented sausages was sometimes regarded as spoilage (Pederson, 1971). Therefore, sourness was an indicator to limit storage time of PV treatment.

There were no significant differences ($p>0.05$) in sour odor of V treatment during 6 days storage. In PA treatment, initial sour odor was not significantly ($p>0.05$) different from those on day 2, 4 and 6 but lower significantly ($p\leq0.05$) at day 8 and 10. For PV treatment, sour odor was constant ($p>0.05$) during the first 8 days of storage and then significantly increased ($p\leq0.05$) 2 days later.

Again, there was no significant difference ($p>0.05$) in juiciness of V treatment stored through 6 days. Juiciness was also stable during storage of PA and PV treatment for the first 8 days, however, it increased significantly ($p\leq0.05$) next 2 days.

There were significant reductions ($p\leq0.05$) in overall acceptability of V, PA and PV treatment when storage time increased. V treatment received overall acceptability score of 0.71 ± 0.14 after 6 days storage while PA treatment received 0.55 ± 0.18 after 10 days storage. It was important to note that panelists rejected PV treatment after 10 days of storage although its mold count was <30 cfu/g as low as initial day. This might be due to the fact that it was too sour.

Table 6. Changes in sensory evaluation of Sai Krok Prew during storage at 30°C.

Treatment*	Storage time (day)					
	0	2	4	6	8	10
Ideal ratio of color before cooking						
A	0.99±0.03	-	-	-	-	-
V	1.00±0.04	0.97±0.07	0.95±0.10	1.04±0.08	-	-
PA	1.00±0.02^{cd}	0.91±0.04^{bc}	0.86±0.15^{ab}	0.93±0.06^{bc}	0.78±0.11^{a}	1.06±0.01^{d}
PV	1.00±0.03^{c}	0.91±0.11^{ab}	0.86±0.13^{a}	0.96±0.05^{bc}	0.88±0.11^{ab}	1.02±0.03^{c}
Ideal ratio of color after cooking						
A	0.99±0.02	-	-	-	-	-
V	0.98±0.02	1.00±0.06	0.96±0.05	1.01±0.11	-	-
PA	0.93±0.02	0.99±0.13	0.95±0.16	0.93±0.12	0.84±0.18	1.00±0.14
PV	0.92±0.02	1.00±0.08	0.94±0.11	0.93±0.09	0.83±0.17	1.00±0.11
Ideal ratio of saltiness						
A	1.03±0.09	-	-	-	-	-
V	1.04±0.11	1.02±0.13	1.00±0.08	1.06±0.14	-	-
PA	1.05±0.17	1.03±0.24	0.90±0.26	1.06±0.13	0.94±0.17	0.88±0.17
PV	1.05±0.15^{b}	1.01±0.08^{b}	0.92±0.15^{ab}	1.06±0.18^{b}	1.02±0.13^{b}	0.82±0.14^{a}
Ideal ratio of sourness						
A	0.97±0.07	-	-	-	-	-
V	0.98±0.07^{a}	1.01±0.09^{ab}	1.08±0.06^{b}	1.21±0.14^{c}	-	-
PA	0.97±0.15^{a}	1.07±0.07^{ab}	1.07±0.19^{ab}	1.20±0.07^{bc}	1.22±0.26^{bc}	1.24±0.17^{c}
PV	0.97±0.12^{a}	1.13±0.10^{bc}	1.06±0.15^{ab}	1.18±0.15^{bcd}	1.26±0.15^{cd}	1.30±0.15^{d}
Ideal ratio of sour odor						
A	0.97±0.04	-	-	-	-	-
V	0.98±0.04	1.00±0.06	1.09±0.18	1.08±0.07	-	-
PA	1.02±0.08^{a}	1.06±0.12^{ab}	1.03±0.25^{a}	1.13±0.08^{ab}	1.20±0.11^{b}	1.36±0.21^{c}
PV	1.02±0.06^{a}	1.07±0.18^{a}	1.05±0.24^{a}	1.16±0.04^{a}	1.16±0.14^{a}	1.34±0.21^{b}
Ideal ratio of stickiness						
A	0.98±0.06	-	-	-	-	-
V	0.99±0.17	0.86±0.22	0.97±0.09	0.94±0.15	-	-
PA	0.99±0.10	0.95±0.21	0.95±0.21	0.95±0.14	0.87±0.20	0.71±0.21
PV	0.98±0.10	0.85±0.18	0.92±0.20	0.93±0.15	0.90±0.20	0.73±0.19
Ideal ratio of juiciness						
A	1.02±0.10	-	-	-	-	-
V	0.98±0.07	1.09±0.11	1.03±0.11	1.04±0.11	-	-
PA	1.05±0.10^{a}	1.09±0.08^{a}	1.08±0.11^{a}	1.01±0.10^{ab}	1.07±0.08^{a}	1.24±0.17^{b}
PV	1.02±0.13^{a}	1.05±0.10^{a}	1.04±0.13^{a}	1.02±0.12^{a}	1.09±0.18^{a}	1.27±0.18^{b}
Ideal ratio of total acceptability						
A	0.82±0.30	-	-	-	-	-
V	0.87±0.16^{c}	0.86±0.07^{bc}	0.74±0.09^{ab}	0.71±0.14^{a}	-	-
PA	0.84±0.11^{d}	0.78±0.10^{cd}	0.68±0.12^{abc}	0.69±0.15^{bc}	0.59±0.07^{ab}	0.55±0.18^{a}
PV	0.85±0.01^{c}	0.74±0.15^{bc}	0.66±0.11^{b}	0.69±0.12^{b}	0.66±0.09^{b}	0.50±0.21^{a}

* A = air packaging of sausage without sorbate; V = vacuum packaging of sausage without sorbate; PA = potassium sorbate treated and air packaging; PV = potassium sorbate treated and vacuum packaging.

$^{a-b}$ Means±S.D. within the same row followed by different superscripts are different ($p \leq 0.05$).

\- No detection.

In conclusion, storage time of A, V and PA treatment was determined by mold populations. Mold counts in A treatment stored 2 days disagreed with the standard value. Shelf life of V and PA was 6 and 10 days respectively. PV treatment with mold counts lower than standard value at least 16 days, had a shelf life defined by sensory result in terms of sourness and total acceptability. Test panels rejected this treatment stored 10 days because it was too sour. Therefore, efficiency of treatments to shelf life extension of Sai Krok Prew was PA>PV>V.

ACKNOWLEDGEMENTS

The authors would like to thank National Science and Technology Development Agency (NSTDA), Thailand for supporting the research fund and Faculty of Agro-Industry, Chiang Mai University for kind assistance in conducting the research work.

REFERENCES

Amundson, C.M., J.G. Sebranek, A.A. Kraft, R.E. Rust, M.K. Wagner, and W.H. Gehrke. 1982. Effect of packaging film and vacuum level on regular and sorbated-cured bacon. Journal of Food Science 47: 355–358, 362.

AOAC. 2000. Official methods of analysis. AOAC International, Maryland, USA.

Bacus, J. 1984. Utilization of microorganisms in meat processing. Research Studies Press Ltd., England.

Baldock, J.D., P.R. Frank, P.P. Graham, and F.J. Ivey. 1979. Potassium sorbate as a fungistatic agent in country ham processing. Journal of Food Protection 42(10): 780–783.

Bozkurt, H., and O. Erkmen. 2002. Effects of starter cultures and additives on the quality of Turkish style sausage (sucuk). Meat Science 61: 149–156.

Chambers, E., J.A. Bowers, K. Prusa, and J. Craig. 1981. Sensory attributes and Instron measurements of reduced-nitrite poultry frankfurters with sorbic acid or potassium sorbate. Journal of Food Science 47: 207–209.

Geminder, J.J. 1959. Use of potassium and sodium sorbate in extending shelf-life of smoked fish. Food Technology 13: 459–461.

Gray, R.J.H., P.H. Elliott, and R.I. Tomlins. 1984. Control of two major pathogens on fresh poultry using a combination potassium sorbate/carbon dioxide packaging treatment. Journal of Food Science 49: 142–145, 179.

Greer, G.G. 1982. Mechanism of beef shelf life extension by sorbate. Journal of Food Protection 45(1): 82–83.

Jay, J.M. 1992. Modern food microbiology. 4th ed., Chapman & Hall, New York.

Kemp, J.D., B.E. Langlois, and J.D. Fox. 1981. Effects of vacuum packaging and potassium sorbate on yield, yeast and mold growth, and quality of dry-cured hams. Journal of Food Science 46: 1015–1017, 1024.

Ministry of Public Health. 1984. Ministry of public health announcement No.84 (BE 2527) on food additives. Ministry of Public Health, Thailand.

Pathomrungsiyungkul, P. 2000. Extending shelf-life of intermediate moisture cured fish using combination of potassium sorbate, modified atmosphere packaging and storage temperation. M.S. Thesis. Chiang Mai University, Chiang Mai, Thailand.

Pederson, C.S. 1971. Microbiology of food fermentations. The AVI Publishing Company, Inc., U.S.A.

Robach, M.C., and J.N. Sofos. 1982. Use of sorbates in meat products, fresh, poultry and poultry pructs: a review. Journal of Food Protection 45(4): 374–383.

Rossi, M. 1993. Packaging under vacuum. p.899–904. In R. Macrae, R.K. Robinson, and M.J. Sadler (eds) Encyclopaedia of food science, food technology and nutrition. vol. 2. Academic Press Limited, London.

Sofos, J. N., and F. F. Busta, 1993. Sorbic acid and sorbates. p.49–94. In P.M. Davidson and A.L. Branen (eds) Antimicrobials in Foods. Marcel Dekker, Inc., New York.

Statham, J.A., H.A. Bremner, and A.R. Quarmby. 1985. Storage of morwong (*Nemadactylus macropterus* Bloch and Schneider) in combinations of polyphosphate, potassium sorbate and carbon dioxide at 4°C. Journal of Food Science 50: 1580–1584, 1587.

Thai Industrial Standards Institute, 1994. Standard of Thai industrial standards institute: fermented pork sausage TSI 1266–1994. Ministry of Industry, Thailand.

Wiriyacharee, P. 2003. Sensory evaluation. Department of Product Development Technology, Faculty of Agro-Industry, Chiang Mai University, Chiang Mai, Thailand.