

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่

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APPENDIX A

COLOUR DETERMINATION

MICROBIOLOGICAL ANALYSIS

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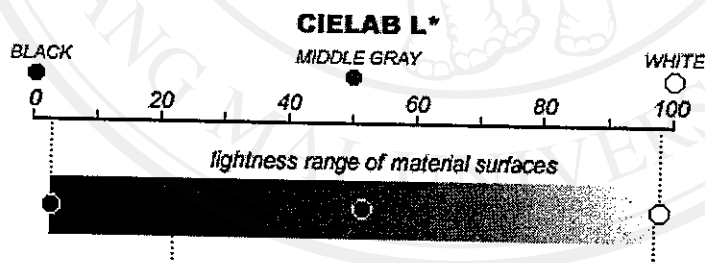
APPENDIX A

Colour determination was performed on all orange juice samples using a colourimeter, Minolta Chroma Meter Model CR-300 Series. The instrument was calibrated with a white tile. The Hunter L*, a*, and b* scale give a measurement of colour in units of approximate visual uniformity throughout a liquid. L* value represented the lightness of colour, a* value represented the greenness and redness and b* value represented the blueness and yellowness.

L* value measures lightness and varies from 100 for perfect white to zero for black.

a* value measures redness when positive (+) and greenness when negative (-) with maximum values of 60.

b* value measures yellowness when positive (+) and blueness when negative (-) with maximum values of 60.



L* = whiteness/darkness, ranged from 0 to 100

Fig A.1 Value range in relation to lightness scales

Where

| | | |
|-------|---|-------------------------|
| 95-99 | = | Near white |
| 86-94 | = | Very light valued |
| 77-85 | = | Light valued |
| 68-76 | = | Moderately light valued |
| 59-67 | = | Mid valued |
| 50-58 | = | Moderately dark valued |
| 41-49 | = | Dark valued |
| 32-40 | = | Very dark valued |
| 31-27 | = | Near black |

a^* = redness for positive value and greenness for the negative one b^* = yellowness for positive and blueness for negative value

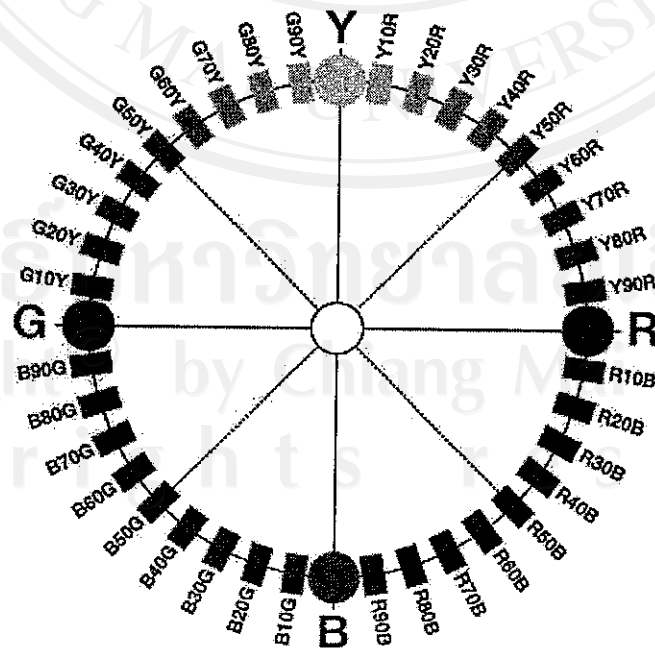


Fig A.2 Colour chart of natural colour system(McGuire, 1992)

Microbiological analysis

Medias

1. Maximum Recovery Diluent: MRD (Merck)

Typical composition (g / litre):

| | |
|-----------------|-----|
| Peptone | 1.0 |
| Sodium chloride | 8.5 |

Preparation:

Dissolve 9.5 g in 1 litre of distilled water. Dispense into final containers and sterilize by autoclaving at 121°C for 15 minutes. The final pH was 7.0±0.2 at 25°C.

2. Orange Serum Agar: OSA (Oxoid)

Typical composition (g / litre):

| | |
|------------------------|------|
| Tryptone | 10.0 |
| Yeast extract | 3.0 |
| Orange Serum | 3.5 |
| Glucose | 4.0 |
| Di-potassium phosphate | 2.5 |
| Agar | 14.0 |

Preparation:

Suspend 37 g in 1 litre of distilled water by heating in a boiling water bath and sterilize by autoclaving at 121°C for 15 minutes.

3. Potato Dextrose Agar: PDA (Oxoid)

Typical composition (g / litre):

| | |
|----------------|------|
| Potato extract | 4.0 |
| Glucose | 20.0 |
| Agar | 15.0 |

Tartaric solution 10% (w/v):

Add 10 g of tartaric acid to 100 ml of distilled water. Sterilize by autoclaving at 121°C for 15 minutes.

Preparation:

Suspend 39 g in 1 litre of distilled water by heating in a boiling water bath and sterilize by autoclaving at 121°C for 15 minutes. Cool to 50°C and aseptically add 0.5% sterile tartaric solution (10% w/v). Mix well and distribute into final containers. The final pH was 5.6±0.2 at 25°C.

4. MRS Agar (DE MAN, ROGOSA and SHARPE): MRS Agar (Merck)

Typical composition (g / litre):

| | |
|--------------------------------|------|
| Peptone from casein | 10.0 |
| Meat extract | 10.0 |
| Yeast extract | 4.0 |
| D (+) Glucose | 20.0 |
| Dipotassium hydrogen phosphate | 2.0 |
| Tween 80 | 1.0 |
| Diammonium hydrogen citrate | 2.0 |
| Sodium acetate | 5.0 |
| Magnesium sulfate | 0.2 |
| Manganese sulfate | 0.04 |
| Agar | 14.0 |

Preparation:

Suspend 66.2 g in 1 litre of distilled water by heating in a boiling water bath and sterilize by autoclaving at 118°C for 15 minutes. The final pH was 5.7±0.2 at 25°C.

US Standard Plate Count Guidance

Diluting samples

1. Work Area

- a. Level plating bench not in direct sunlight.
- b. Sanitized immediately before start of plating.

2. Selecting Dilutions

- a. Plate three decimal dilutions per sample.
- b. Select dilutions to yield one plate with 30-300 colonies.

3. Identifying Plates

- a. Label each plate with sample identification and dilution.
- b. Arrange plates in order before preparation of dilutions.

4. Sample Agitation

- a. When appropriate, wipe top of unopened containers with sterile, ethyl alcohol- saturated cloth.
- b. Remove test portion within 3 min of sample agitation.

5. Sample Measurement, pipettes

- a. Use separate sterile pipettes for the initial transfers from each container: Pipettes in pipette container adjusted without touching the pipettes.
- b. Pipette tip not dragged over exposed exterior of pipettes in container.
- c. Pipette not dragged across lip or neck of sample container.
- d. Pipette not inserted more than 2.5 cm (1") below sample surface (foam avoided if possible).
- e. Draw test portion above pipette graduation mark and remove pipette from liquid: pipette aid used, mouth pipetting not permitted.

f. Adjust test volume to mark with lower side of pipette in contact with inside of sample container (above the sample surface).

g. Drainage complete, excess liquid not adhering to pipette.

h. Release test portion to Petri dish (tip in contact with plate, 45° angle) or dilution blank (with lower side of pipette in contact with neck of dilution blank, or dry area above buffer where appropriate) with column drain of 2-4 sec.

i. Blow out last drop of undiluted sample from pipette using pipette aid: Blow out away from main part of sample in plate, do not make bubbles.

j. Pipettes discarded into disinfectant, or if disposable into biohazard bags or containers to be sterilized.

6. Dilution Agitation

a. Optionally, use approved mechanical shaker for 15 sec.

b. Remove test portion within 3 min of dilution agitation.

7. Dilution Measurement, pipettes

a. Use separate sterile pipettes for the initial transfers from each container:
pipettes in pipette container adjusted without touching the pipettes.

b. Pipette tip not dragged over exposed exterior of pipettes in container.

c. Pipette not dragged across lip or neck of dilution blank.

d. Pipette not inserted more than 2.5 cm below dilution surface.

e. Draw dilution portion above pipette graduation mark and remove pipette from liquid: pipette aid used, mouth pipetting not permitted.

f. Adjust dilution volume to mark with lower side of pipette in contact with inside of dilution blank neck.

g. Drainage complete, excess liquid not adhering to pipette.

h. Gently lift cover of petri dish just high enough to insert pipette.

i. Hold pipette at 45° angle to dish with tip touching dish (or dilution blank neck).

j. Release dilution portion to dish (or dilution blank) with tip in contact with the bottom of the dish (or dilution blank neck, or dry area above buffer where appropriate) with column drain of 2-4 sec.

- k. Touch pipette tip once against dry spot on dish bottom (or dilution blank neck): when measuring 0.1 ml, do not re-touch dry area.

8. Plating

- a. Melt agar quickly in boiling water, flowing steam not under pressure, or microwave oven (use extreme caution when microwaving).
- b. Avoid prolonged exposure to high temperatures during and after melting, establish lab protocol.
- c. Do not melt more than will be used within 3 hours.
- d. Do not melt agar more than once.
- e. Promptly cool melted agar to $45\pm 1^{\circ}\text{C}$: record temperature with other control information.
- f. Temperature control used for each test medium type:
 - 1. Contains medium identical to type being used.
 - 2. In container identical to type being used.
 - 3. Undergoes same heat treatment and cooling as test medium.
- g. Select number of samples in any series so that all will be plated within 20 min after diluting first sample.
- h. After depositing test portions, promptly pour 10-12 ml medium into each plate of series, or 15-20 ml for > 1 ml portion/plate or where agar weight loss is a problem that can not be corrected by other actions (documentation must be kept to indicate that this is a routine practice).
- i. Lift cover of petri dish just high enough to pour medium.
- j. As each plate is poured thoroughly and evenly mix medium and test portion in petri dish: multiple plates may be poured and mixed, however, plates may not be stacked prior to mixing.
- k. Allow to solidify within 10 min on level surface.

9. Controls

- a. Check sterility of dilution blanks, medium, petri dishes and pipettes used for each group of samples.

10. Counting colonies

- a. Count colonies with aid of magnification under uniform and properly controlled artificial illumination with a hand tally.

11. Recording Standard Plate Count

- a. After incubating plates, promptly count all colonies on selected plates.
- b. Where impossible to count at once, store plates at 0-4.4⁰C for not longer than 24 hr (avoid as a routine practice).
- c. Record dilutions used and number of colonies on each plate counted.
- d. Record results of sterility and control tests.
- e. When possible, select spreader free plates with 30-300 colonies and count all colonies:
 1. Use higher magnification if necessary to distinguish colonies from foreign matter.
 2. Examine edge of plates for colonies.
- f. If consecutive plates yield 30-300 colonies, count all colonies on plate from both dilutions.
- g. Count chains from separate source as separate colonies.
- h. If there is no 30-300 colony plate, use plate having nearest to 30-300 colonies.
- i. If plates from all dilutions exceed 300 colonies, estimate counts as follow:
 1. Count colonies in portions representative of distribution and estimate total.
 2. Where there are < 10 colonies/sq cm, count colonies in 12 squares, selecting 6 consecutive squares horizontally across the plate and 6 consecutive squares at right angles.
 3. When there are 10 or more colonies/sq cm, count 4 representative squares.
 4. Multiply average number colonies/sq cm by area of plate in sq cm.
- j. If plates yield < 30 colonies each, record actual number in lowest dilution.
- k. If all plates from a sample show no colonies, record count as 0.

12. Personal Errors

- a. Avoid inaccurate counting due to carelessness, fatigue or impaired vision.
- b. Discover cause and correct if unable to duplicate your own counts on the same plate.

13. Computing and Reporting Counts

- a. Multiply number of colonies (or estimated number if necessary) by the reciprocal of the dilution.
- b. If consecutive dilutions yield 30-300 colonies, compute count using formula below:

$$N = \Sigma C / [(1 \times n_1) + (0.1 \times n_2)]d$$

Where ;

 N = number of colonies per milliliter or gram ΣC = sum of all colonies on all plates counted n_1 = number of plates in lower dilution counted n_2 = number of plates in next highest dilution counted d = dilution from which the first counts were obtained

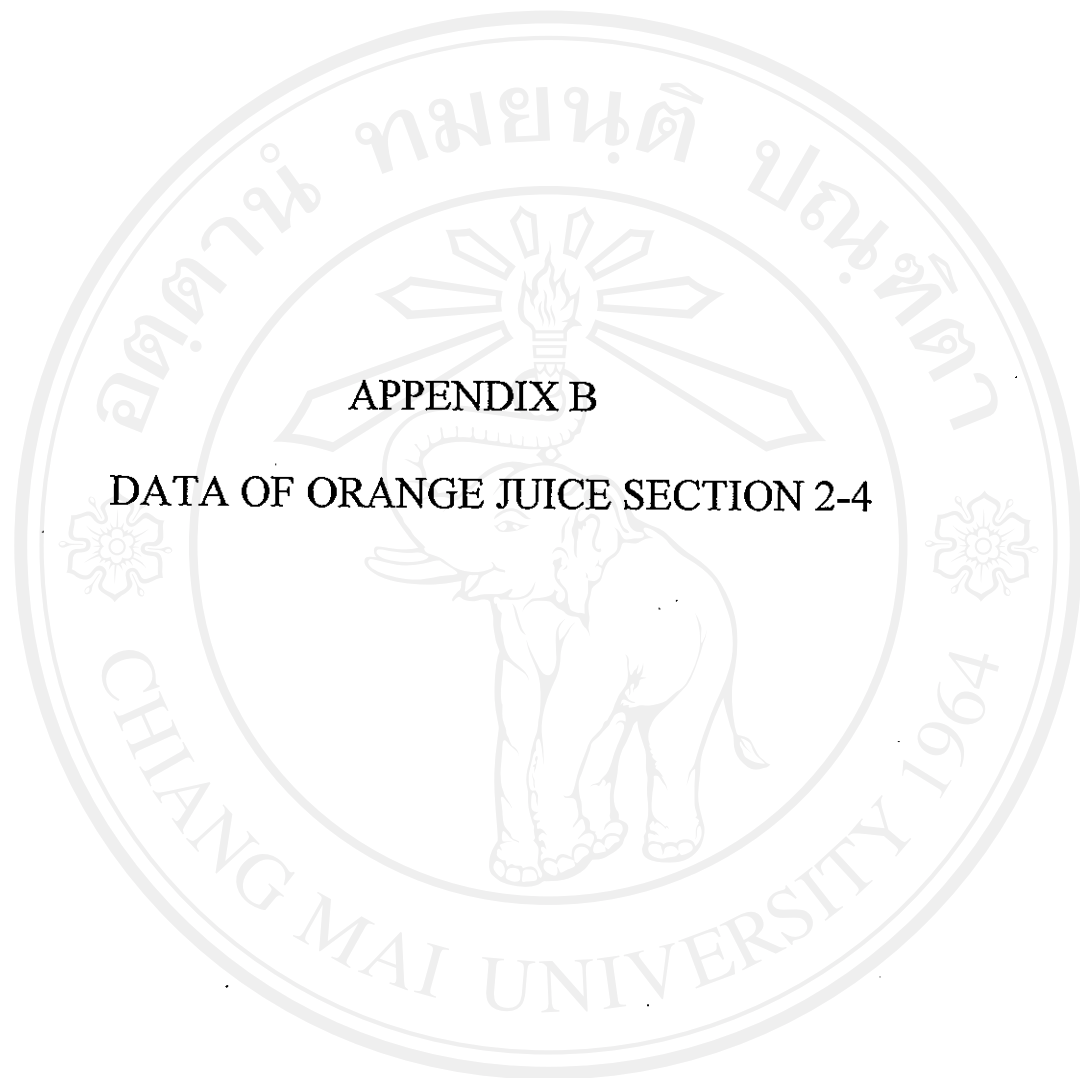
Example; 1:100 = 244 colonies and 1:1,000 = 38 colonies

$$N = (244 + 38) / [(1 \times 1) + (0.1 \times 1)]0.01$$

$$= 282 / [1.1]0.01$$

$$= 282 / 0.011$$

$$= 25,636$$



APPENDIX B

DATA OF ORANGE JUICE SECTION 2-4

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่

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Table A4.1 Sensory properties of orange juice at the first day storage

| Method | Appearance | Colour | Odour | Turbidity | Sweet | Sour | Overall |
|---------------------|------------|---------|----------|-----------|---------|---------|----------|
| Srt | 7.25 cd | 7.28 d | 7.10 bc | 6.92 | 7.23 b | 6.98 ab | 7.60 c |
| Krt | 6.93 bcd | 7.08 cd | 7.00 bc | 6.98 | 7.23 b | 7.22 b | 7.15 b c |
| S ₄ | 6.70 bc | 6.68 bc | 6.72 abc | 6.30 | 6.98 ab | 6.65 ab | 6.83 ab |
| K ₄ | 7.38 d | 7.43 d | 7.13 c | 6.90 | 7.03 ab | 6.72 ab | 7.38 c |
| S-18 | 6.38 ab | 6.33 ab | 6.43 a | 6.58 | 6.58 a | 6.48 a | 6.58 a |
| K-18 | 5.98 a | 5.95 a | 6.60 ab | 6.43 | 6.56 a | 6.41 a | 6.53 a |
| LSD _{0.05} | * | * | * | ns | * | * | * |

Values are means

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.2 Changes in colour L* in orange juice during storage at room temperature, 4 and -18°C

| Methods | Colour L* | | | | | | | | | | |
|------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----|----|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _r | 27.45 ^a ±4.14 | 29.03 ^b ±9.54 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| K _r | 37.18 ^b ±4.04 | 37.32 ^c ±9.07 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| S ₄ | 29.20 ^b ±7.50 | 29.20 ^b ±7.50 | 28.90 ^b ±0.38 | 24.86 ^d ±0.24 | ND | ND | ND | ND | ND | ND | ND |
| K ₄ | 37.31 ^b ±8.54 | 38.43 ^c ±0.18 | 38.43 ^d ±0.18 | 37.98 ^c ±0.36 | ND | ND | ND | ND | ND | ND | ND |
| S ₋₁₈ | 27.84 ^a ±0.24 | 27.14 ^a ±0.22 | 27.18 ^a ±0.20 | 27.05 ^a ±0.0 | 27.06 ^a ±1.01 | 26.79 ^a ±8.32 | 27.43 ^a ±1.18 | 37.42 ^a ±0.32 | 37.44 ^a ±0.29 | | |
| K ₋₁₈ | 37.93 ^b ±0.32 | 37.94 ^d ±0.10 | 37.96 ^c ±8.02 | 37.94 ^c ±6.92 | 37.95 ^c ±6.12 | 39.32 ^c ±0.71 | 39.46 ^c ±0.63 | 36.93 ^c ±0.24 | 36.90 ^c ±0.23 | | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements.

Values followed by different letters are significantly different (p < 0.05).

Table A4.3 Changes in colour a* in orange juice during storage at room temperature, 4 and -18°C

| Methods | Colour a* | | | | | | | | | | |
|-----------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _{RT} | 1.20 ^a ± 0.81 | 0.83 ^a ± 0.02 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| K _{RT} | 2.58 ^b ± 0.03 | 2.47 ^d ± 0.06 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| S4 | 0.82 ^a ± 0.02 | 0.82 ^a ± 0.02 | 0.84 ^a ± 0.04 | 3.96 ^a ± 0.05 | ND | ND | ND | ND | ND | ND | ND |
| K4 | 2.46 ^b ± 0.06 | 2.29 ^c ± 0.04 | 2.30 ^c ± 0.03 | 3.33 ^b ± 0.07 | ND | ND | ND | ND | ND | ND | ND |
| S-18 | 0.96 ^a ± 0.05 | 1.00 ^b ± 0.04 | 0.99 ^b ± 0.04 | 0.94 ^a ± 0.08 | 0.95 ± 0.08 | 0.89 ± 0.03 | 0.89 ± 0.03 | 2.60 ± 0.08 | 2.60 ± 0.08 | 2.60 ± 0.08 | 2.60 ± 0.08 |
| K-18 | 2.34 ^b ± 0.07 | 2.32 ^c ± 0.03 | 2.32 ^c ± 0.03 | 2.22 ^b ± 0.04 | 2.22 ± 0.04 | 2.18 ± 0.31 | 2.14 ± 0.30 | 2.67 ± 1.00 | 2.67 ± 1.00 | 2.67 ± 1.00 | 2.67 ± 1.00 |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different (p < 0.05).

Table A.4.4 Changes in colour b* in orange juice during storage at room temperature, 4 and -18°C

| Methods | Colour b* | | | | | | | | | | |
|-----------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _{rt} | 19.09 ^a ±8.29 | 13.46 ^b ±3.22 | ND | ND | ND | ND | ND | ND | ND | ND | |
| K _{rt} | 23.88 ^b ±0.12 | 23.80 ^d ±0.11 | ND | ND | ND | ND | ND | ND | ND | ND | |
| S4 | 13.88 ^a ±0.08 | 13.87 ^c ±0.82 | 13.49 ^b ±0.48 | 12.17 ^a ±0.23 | ND | ND | ND | ND | ND | ND | |
| K4 | 23.80 ^b ±0.11 | 26.37 ^f ±0.24 | 26.51 ^e ±0.12 | 24.61 ^b ±2.93 | ND | ND | ND | ND | ND | ND | |
| S-18 | 12.16 ^a ±0.23 | 11.33 ^a ±0.22 | 11.37 ^a ±0.20 | 11.13 ^a ±0.12 | 11.14 ^a ±0.12 | 10.82 ^a ±8.74 | 10.81 ^a ±8.54 | 23.87 ^a ±0.32 | 23.85 ^a ±0.32 | | |
| K-18 | 24.08 ^b ±2.63 | 26.08 ^e ±7.57 | 26.07 ^e ±7.10 | 26.05 ^b ±1.53 | 26.05 ^a ±1.53 | 24.37 ^a ±1.18 | 24.56 ^a ±1.10 | 24.95 ^a ±0.17 | 24.93 ^a ±0.17 | | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different (p < 0.05).

Table A4.5 Changes in total soluble solids in orange juice during storage at room temperature, 4 and-18°C

| Methods | Total soluble solids (brix) | | | | | | | | | | |
|----------------|-----------------------------|---------------------------|---------------------------|--------------------------|------------|------------|------------|------------|------------|----|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _r | 11.93 ^c ±0.06 | 11.80 ^{bc} ±1.00 | ND | ND | ND | ND | ND | ND | ND | ND | |
| K _r | 11.46 ^a ±0.12 | 11.43 ^a ±0.06 | ND | ND | ND | ND | ND | ND | ND | ND | |
| S4 | 11.86 ^{bc} ±0.06 | 11.73 ^b ±0.21 | 11.60 ^{ab} ±0.17 | 9.40 ^a ±0.46 | ND | ND | ND | ND | ND | ND | |
| K4 | 11.40 ^a ±0.00 | 11.43 ^a ±0.15 | 11.40 ^a ±1.00 | 9.90 ^b ±1.00 | ND | ND | ND | ND | ND | ND | |
| S-18 | 11.80 ^b ±0.10 | 11.83 ^c ±0.12 | 11.76 ^b ±0.12 | 11.70 ^c ±0.00 | 11.13±0.32 | 11.06±0.21 | 11.03±0.23 | 11.00±0.26 | 10.90±0.26 | | |
| K-18 | 11.40 ^a ±0.01 | 11.53 ^{ab} ±0.23 | 11.43 ^a ±0.15 | 11.40 ^c ±1.00 | 11.33±0.06 | 11.33±5.72 | 11.33±5.77 | 11.30±0.10 | 11.33±5.77 | | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different (p < 0.05).

Table A4.6 Changes in total titratable acidity in orange juice during storage at room temperature, 4 and -18°C

| Methods | Total titratable acidity (%) | | | | | | | | | | |
|---------|------------------------------|-------------------------|-------------------------|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S(rt) | 0.65 ^b ±0.15 | 0.71 ^d ±0.05 | ND | ND | ND | ND | ND | ND | ND | ND | |
| K(rt) | 0.52 ^a ±0.17 | 0.62 ^c ±0.01 | ND | ND | ND | ND | ND | ND | ND | ND | |
| S4 | 0.64 ^b ±0.05 | 0.63 ^c ±0.02 | 0.62 ^b ±0.05 | 0.71 ^d ±0.05 | ND | ND | ND | ND | ND | ND | |
| K4 | 0.53 ^a ±0.02 | 0.52 ^a ±0.01 | 0.52 ^a ±0.01 | 0.62 ^b ±0.05 | ND | ND | ND | ND | ND | ND | |
| S-18 | 0.64 ^b ±0.01 | 0.63 ^c ±0.01 | 0.64 ^c ±0.00 | 0.68 ^c ±0.05 | 0.65±0.04 | 0.65±0.03 | 0.66±0.05 | 0.68±0.01 | 0.68±0.05 | 0.68±0.05 | |
| K-18 | 0.58 ^a ±0.02 | 0.55 ^b ±0.02 | 0.54 ^a ±0.01 | 0.57 ^a ±0.02 | 0.57±0.02 | 0.58±0.02 | 0.56±0.03 | 0.56±0.01 | 0.64±0.01 | 0.64±0.01 | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.7 Changes in pH in orange juice during storage at room temperature, 4 and-18°C

| Methods | pH | | | | | | | | | | |
|------------------|---------------------------|-------------------------|-------------------------|-------------------------|-----------|-----------|-----------|-----------|-----------|----|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S ₁₁ | 4.90 ^c ±0.00 | 3.30 ^a ±0.26 | ND | ND | ND | ND | ND | ND | ND | ND | |
| K ₁₁ | 4.76 ^a ±0.05 | 3.23 ^a ±0.06 | ND | ND | ND | ND | ND | ND | ND | ND | |
| S ₄ | 4.86 ^{abc} ±0.05 | 4.03 ^b ±0.15 | 3.80 ^a ±0.00 | 3.26 ^a ±0.05 | ND | ND | ND | ND | ND | ND | |
| K ₄ | 4.80 ^{ab} ±0.00 | 4.83 ^c ±0.05 | 3.76 ^a ±0.05 | 3.26 ^a ±0.05 | ND | ND | ND | ND | ND | ND | |
| S ₋₁₈ | 4.83 ^{abc} ±0.05 | 4.50 ^c ±0.30 | 4.06 ^b ±0.05 | 3.76 ^b ±0.05 | 3.73±0.05 | 3.60±0.00 | 3.56±0.05 | 3.43±0.05 | 3.36±0.12 | | |
| K ₋₁₈ | 4.83 ^{abc} ±0.05 | 4.76 ^c ±0.05 | 4.53 ^c ±0.05 | 4.36 ^c ±0.05 | 4.13±0.20 | 4.23±0.05 | 4.23±0.05 | 4.30±0.00 | 4.10±0.01 | | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different (p < 0.05).

Table A4.8 Changes in reducing sugars in orange juice during storage at room temperature, 4 and-18°C

| Methods | Reducing sugars (mg/100g) | | | | | | | | | | |
|----------------|---------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----|----|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _π | 3.46 ^b ±0.17 | 1.17 ^a ±0.09 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| K _π | 2.83 ^a ±0.11 | 1.07 ^a ±0.07 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| S4 | 3.49 ^b ±0.14 | 2.05 ^b ±0.12 | 1.81 ^b ±0.05 | 1.32 ^b ±0.07 | ND | ND | ND | ND | ND | ND | ND |
| K4 | 2.81 ^a ±0.09 | 1.78 ^b ±0.22 | 1.24 ^a ±0.15 | 1.04 ^a ±0.03 | ND | ND | ND | ND | ND | ND | ND |
| S-18 | 3.61 ^b ±0.05 | 2.93 ^c ±0.09 | 2.82 ^c ±0.03 | 2.74 ^d ±1.00 | 2.46 ^c ±0.34 | 2.32 ^c ±0.13 | 1.96 ^c ±0.02 | 1.90 ^c ±0.13 | 1.96 ^c ±0.07 | | |
| K-18 | 2.85 ^a ±0.06 | 2.61 ^c ±0.40 | 2.63 ^c ±0.12 | 2.50 ^c ±0.07 | 2.72 ^c ±0.21 | 2.33 ^c ±0.06 | 2.10 ^c ±0.09 | 1.53 ^c ±0.09 | 1.37 ^c ±0.02 | | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different (p < 0.05).

Table A4.9 Changes in ascorbic acid in orange juice during storage at room temperature, 4 and-18°C

| Methods | Ascorbic acid (mg/100g) | | | | | | | | | | |
|-----------------|--------------------------|--------------|--------------------------|--------------------------|--------------|--------------|-------------|-------------|--------------|----|----|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _{rt} | 28.23 ^b ±0.25 | 18.43 ± 0.58 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| K _{rt} | 25.33 ^a ±0.31 | 14.60 ± 0.60 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| S4 | 28.23 ^b ±0.25 | 25.83±0.12 | 25.63 ^b ±0.30 | 9.93 ^b ±0.40 | ND | ND | ND | ND | ND | ND | ND |
| K4 | 25.33 ^a ±0.30 | 19.67±0.18 | 18.93 ^a ±0.80 | 8.40 ^a ±0.98 | ND | ND | ND | ND | ND | ND | ND |
| S-18 | 28.23 ^b ±0.25 | 25.63±0.55 | 25.33 ^b ±1.42 | 20.43 ^b ±0.15 | 20.36±5.77 | 19.06 ± 0.60 | 16.73 ±2.88 | 14.23 ±0.12 | 11.66 ± 0.58 | | |
| K-18 | 25.33 ^a ±.30 | 21.33±5.77 | 21.06 ^a ±1.90 | 10.26 ^b ±0.65 | 10.23 ± 5.77 | 9.53 ±0.31 | 8.00 ± 4.46 | 7.33 ±5.77 | 6.26 ±0.21 | | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different (p < 0.05).

Table A4.10 Changes in Yeast and Mould in orange juice during storage at room temperature, 4 and-18°C

| Methods | Yeast and Mould (CFU/ml) | | | | | | | | | | |
|-----------------|--------------------------|--------|--------|--------|--------|---------|---------|---------|---------|-----|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _{rt} | <10 | <10 | 90 | ND | ND | ND | ND | ND | ND | ND | |
| K _{rt} | <10 | <10 | 50 | ND | ND | ND | ND | ND | ND | ND | |
| S4 | <10 | <10 | <10 | <10 | 70 | ND | ND | ND | ND | ND | |
| K4 | <10 | <10 | <10 | <10 | 63 | ND | ND | ND | ND | ND | |
| S-18 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | |
| K-18 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | |

ND = not detectable
 Values are means ± standard deviations for triplicate measurements

Table A4.1.1 Changes in Lactic acid bacteria in orange juice during storage at room temperature, 4 and-18°C

| Methods | Lactic acid bacteria (CFU/ml) | | | | | | | | | | |
|----------------|-------------------------------|--------|--------|--------|--------|---------|---------|---------|---------|-----|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _r | <10 | <10 | 34 | ND | ND | ND | ND | ND | ND | ND | |
| K _r | <10 | <10 | 36 | ND | ND | ND | ND | ND | ND | ND | |
| S4 | <10 | <10 | <10 | <10 | 40 | ND | ND | ND | ND | ND | |
| K4 | <10 | <10 | <10 | <10 | 34 | ND | ND | ND | ND | ND | |
| S-18 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | |
| K-18 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | |

ND = not detectable
 Values are means ± standard deviations for triplicate measurements

Table A4.12 Changes in spore count in orange juice during storage at room temperature, 4 and-18°C

| Methods | Spore count (CFU/ml) | | | | | | | | | | |
|----------------|----------------------|--------|--------|--------|--------|---------|---------|---------|---------|-----|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S _r | <10 | <10 | 30 | ND | ND | ND | ND | ND | ND | ND | |
| K _r | <10 | <10 | 35 | ND | ND | ND | ND | ND | ND | ND | |
| S4 | <10 | <10 | <10 | <10 | 31 | ND | ND | ND | ND | ND | |
| K4 | <10 | <10 | <10 | <10 | 33 | ND | ND | ND | ND | ND | |
| S-18 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | |
| K-18 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | |

ND = not detectable
 Values are means ± standard deviations for triplicate measurements

Table A4.13 Changes in total carotenoid content in orange juice during storage at room temperature, 4 and -18°C

| Methods | Total carotenoid content (µg/100g) | | | | | | | | | | |
|---------|------------------------------------|----------------------------|----------------------------|----------------------------|--------------|-------------|-------------|-------------|-------------|-------------|--|
| | 0 days | 1 days | 3 days | 6 days | 9 days | 12 days | 15 days | 18 days | 21 days | | |
| S(rt) | 116.2 ^b ± 0.15 | 1.67 ^d ± 0.05 | ND | ND | ND | ND | ND | ND | ND | ND | |
| K(rt) | 92.87 ^a ± 0.17 | 0.97 ^c ± 0.01 | ND | ND | ND | ND | ND | ND | ND | ND | |
| S4 | 116.2 ^b ± 0.05 | 95.47 ^b ± 0.05 | 95.47 ^b ± 0.05 | 64.23 ^d ± 0.05 | ND | ND | ND | ND | ND | ND | |
| K4 | 92.87 ^a ± 0.02 | 79.90 ^a ± 0.01 | 79.90 ^a ± 0.01 | 51.87 ^b ± 0.05 | ND | ND | ND | ND | ND | ND | |
| S-18 | 116.2 ^b ± 0.05 | 109.77 ^c ± 0.00 | 109.77 ^c ± 0.00 | 109.77 ^c ± 0.05 | 92.87 ± 0.04 | 1.40 ± 0.05 | 1.40 ± 0.05 | 1.40 ± 0.05 | 1.40 ± 0.05 | 1.40 ± 0.05 | |
| K-18 | 92.87 ^a ± 0.02 | 92.9 ^a ± 0.01 | 92.9 ^a ± 0.01 | 91.9 ^a ± 0.02 | 78.97 ± 0.02 | 5.97 ± 0.03 | 5.97 ± 0.03 | 5.97 ± 0.03 | 5.97 ± 0.03 | 5.97 ± 0.03 | |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.14 Effect of nisin and pH on colour L* in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Colour L* | | | | | | | | |
|---------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 49.61±0.45 ^{ab} | 49.77±0.20 ^{ab} | 49.28±0.81 ^a | 52.32±0.42 ^d | 52.25±0.07 ^d | 51.89±0.25 ^d | 51.33±0.47 ^{cd} | 51.65±1.19 ^d | 50.54±0.02 ^{bc} |
| 3 | 49.46±0.31 ^b | 49.450.33 ^b | 48.67±0.27 ^b | 50.64±0.37 ^{de} | 51.14±0.68 ^{ef} | 50.11±0.06 ^{cd} | 51.26±0.05 ^f | 49.85±0.09 ^{bc} | 50.56±0.01 ^d |
| 6 | 49.48±0.03 ^b | 49.18±0.21 ^b | 47.50±0.04 ^a | 50.66±0.42 ^e | 50.05±0.02 ^d | 50.12±0.04 ^d | 51.63±0.10 ^f | 49.62±0.29 ^{cd} | 50.33±0.23 ^e |
| 9 | 51.43±0.06 ^d | 49.48±0.33 ^b | 47.64±0.09 ^a | 50.25±0.08 ^c | 50.04±0.02 ^{bc} | 50.23±0.22 ^e | 51.93±0.25 ^d | 49.51±0.85 ^b | 49.85±0.09 ^{bc} |
| 12 | 51.39±0.07 ^e | 49.06±0.29 ^c | 47.62±0.17 ^a | 50.23±0.12 ^d | 50.26±0.08 ^d | 48.30±0.24 ^b | 51.10±0.31 ^e | 49.95±0.07 ^d | 48.90±3.33 ^c |
| 15 | 50.78±1.23 ^c | 49.01±0.31 ^b | 47.48±0.22 ^a | 50.14±0.01 ^c | 50.29±0.02 ^c | 48.09±0.10 ^a | 50.72±0.15 ^c | 49.27±0.45 ^b | 49.00±0.49 ^b |
| 18 | 50.41±0.06 ^d | 49.03±0.48 ^b | 47.83±0.37 ^a | 50.02±0.07 ^d | 50.29±0.09 ^b | 48.15±0.04 ^a | 50.42±0.13 ^d | 49.54±0.16 ^c | 49.14±0.37 ^{bc} |
| 21 | 50.42±0.04 ^f | 48.65±0.28 ^{bc} | 47.64±1.78 ^a | 49.85±0.01 ^{ef} | 50.23±0.14 ^{ab} | 48.24±0.82 ^g | 51.19±0.19 ^{de} | 49.31±0.19 ^{de} | 49.01±0.51 ^{cd} |
| 24 | 50.65±1.16 ^c | 48.82±0.43 ^b | 47.67±0.34 ^a | 49.74±0.06 ^{cd} | 50.32±0.06 ^{de} | 48.61±0.06 ^b | 48.72±0.02 ^b | 49.26±0.01 ^{bc} | 48.65±0.13 ^b |
| 27 | 51.37±0.04 ^g | 48.9±0.66 ^{cd} | 47.69±0.08 ^{cd} | 49.92±0.13 ^c | 50.54±0.12 ^c | 48.25±0.34 ^b | 48.73±0.04 ^c | 49.30±0.09 ^d | 48.66±0.03 ^{bc} |
| 30 | 51.37±0.01 ^g | 49.4±0.05 ^{de} | 47.29±0.12 ^a | 49.88±0.70 ^{ef} | 50.31±0.27 ^f | 48.10±0.03 ^b | 48.71±0.18 ^c | 49.14±0.03 ^{cd} | 48.76±0.11 ^c |
| 33 | 54.60±0.83 | 49.16±0.76 | 47.35±0.06 | 49.65±0.18 | 50.15±0.03 | 48.17±0.01 | 48.67±0.11 | 49.18±0.08 | 48.79±0.07 |
| 36 | 51.69±0.46 ^f | 48.79±0.08 ^c | 48.09±0.28 ^b | 49.63±0.04 ^e | 46.74±0.16 ^a | 48.71±0.18 ^c | 48.91±0.23 ^{cd} | 49.30±0.33 ^{de} | 47.14±0.07 ^a |
| 39 | 52.01±0.47 ^e | 48.71±0.08 ^c | 47.86±0.05 ^b | 49.61±0.02 ^d | 47.00±0.27 ^a | 48.71±0.18 ^c | 48.84±0.04 ^c | 48.53±0.45 ^{de} | 48.33±0.89 ^{bc} |
| 42 | 51.65±0.35 ^c | 48.33±0.38 ^{ab} | 48.00±0.27 ^{ab} | 33.09±0.02 ^{bc} | 46.76±3.22 ^a | 48.52±0.02 ^{ab} | 47.93±1.59 ^{ab} | 46.79±0.13 ^a | 48.20±0.22 ^{ab} |

Values are means ± standard deviations for triplicate measurements
 Values followed by different letters are significantly different ($p < 0.05$).

Table A4.15 Effect of nisin and pH on colour L* in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Colour L* | | | | | | | | |
|------------------------|--------------------------|--------------------------|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 55.15±0.31 ^{bc} | 53.59±2.38 ^{ab} | 56.59±0.83 ^c | 53.11±0.51 ^a | 52.33±0.06 ^a | 53.48±0.70 ^a | 52.75±0.31 ^a | 52.66±0.26 ^{bc} | 52.94±0.55 ^a |
| 3 | 54.83±1.05 ^c | 51.98±0.14 ^a | 56.81±0.07 ^f | 53.93±0.06 ^d | 52.38±0.09 ^{ab} | 53.75±0.09 ^d | 53.07±0.06 ^c | 52.78±0.07 ^{bc} | 52.71±0.20 ^{bc} |
| 6 | 56.32±1.04 ^a | 50.52±0.70 ^a | 55.72±0.96 ^d | 54.08±0.26 ^c | 52.33±3.51 ^b | 52.86±0.04 ^b | 53.12±0.13 ^b | 52.33±0.04 ^b | 52.53±0.03 ^d |
| 9 | 54.64±1.30 ^d | 50.66±0.09 ^a | 57.23±1.23 ^e | 53.88±0.09 ^{cd} | 52.44±0.13 ^b | 53.40±0.61 ^{bc} | 52.94±0.27 ^{bc} | 52.44±0.34 ^b | 52.64±0.10 ^b |
| 12 | 54.53±0.22 ^{ab} | 50.56±0.09 ^{ab} | 56.45±1.15 ^b | 54.02±0.04 ^{ab} | 52.39±0.39 ^{ab} | 36.03±0.28 ^a | 53.49±0.20 ^{ab} | 52.51±0.26 ^{ab} | 52.50±0.02 ^{ab} |
| 15 | 55.22±0.55 ^{bc} | 53.14±1.79 ^a | 56.50±2.21 ^e | 54.01±0.07 ^{ab} | 52.33±0.03 ^a | 52.58±0.03 ^a | 53.14±0.44 ^a | 52.39±0.03 ^a | 52.55±0.33 ^a |
| 18 | 55.23±0.74 ^b | 53.92±0.15 ^c | 53.12±0.84 ^b | 54.13±0.10 ^d | 52.23±0.15 ^a | 52.46±0.26 ^{ab} | 52.89±0.31 ^{ab} | 52.45±0.07 ^{ab} | 52.47±0.02 ^{ab} |
| 21 | 55.00±0.28 ^c | 50.41±0.05 ^a | 52.60±0.03 ^b | 54.00±0.11 ^d | 52.34±0.02 ^b | 52.37±0.22 ^b | 53.28±0.16 ^c | 52.46±0.16 ^b | 52.61±0.02 ^b |
| 24 | 54.97±0.30 ^d | 50.55±0.30 ^a | 53.65±0.96 ^c | 53.96±0.01 ^c | 52.33±0.03 ^b | 52.55±0.26 ^b | 53.01±0.10 ^b | 52.48±0.23 ^b | 52.57±0.06 ^b |
| 27 | 55.23±0.92 ^a | 50.36±0.15 ^a | 53.63±0.55 ^d | 53.70±0.49 ^d | 52.28±0.05 ^b | 52.43±0.06 ^b | 53.33±0.33 ^{cd} | 52.20±0.07 ^b | 52.62±0.04 ^{bc} |
| 30 | 54.26±1.12 ^c | 50.40±0.07 ^a | 53.38±0.92 ^{cd} | 53.55±0.28 ^{de} | 52.18±0.02 ^{bc} | 52.42±0.03 ^{cd} | 52.82±0.24 ^{cd} | 52.22±0.02 ^{bc} | 51.20±1.26 ^{ab} |
| 33 | 54.74±0.54 ^{ab} | 50.33±0.02 ^a | 52.82±0.11 ^c | 53.50±0.01 ^f | 52.32±0.10 ^{cd} | 52.58±0.07 ^{bc} | 52.36±0.05 ^{cd} | 52.16±0.07 ^c | 51.00±0.07 ^b |
| 36 | 55.95±0.74 ^f | 50.30±0.04 ^a | 52.82±0.11 ^c | 53.42±0.26 ^c | 52.27±0.04 ^{cd} | 52.54±0.11 ^{cd} | 52.76±0.43 ^{cd} | 52.20±0.03 ^c | 50.99±0.02 ^b |
| 39 | 56.53±0.23 ^e | 50.27±0.05 ^a | 52.92±0.89 ^{bcd} | 53.54±0.05 ^d | 52.38±0.05 ^{bc} | 53.08±0.96 ^{cd} | 53.29±0.06 ^d | 52.21±0.03 ^b | 50.93±0.12 ^a |
| 42 | 56.44±0.13 ^d | 50.58±0.11 ^a | 53.45±1.05 ^c | 53.55±0.03 ^c | 52.09±0.36 ^b | 50.71±0.19 ^a | 52.61±0.30 ^b | 34.78±0.01 ^b | 51.05±0.04 ^a |

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.16 Effect of nisin and pH on colour a* in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Colour a* | | | | | | | | |
|------------------------|---------------------------|--------------------------|--------------------------|--------------------------|---------------------------|-------------------------|-------------------------|--------------------------|-------------------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 5.02±0.38 ^c | 4.59±0.03 ^{bc} | 4.21±0.44 ^{ab} | 3.96±0.25 ^a | 4.18±0.12 ^{ab} | 4.33±0.18 ^a | 4.56±0.28 ^{bc} | 3.90±0.33 ^a | 4.58±0.03 ^{bc} |
| 3 | 4.61±0.09 ^{abc} | 4.10±0.71 ^{ab} | 4.59±0.03 ^{abc} | 4.66±0.46 ^{abc} | 3.95±0.78 ^a | 4.72±0.04 ^{bc} | 4.87±0.04 ^c | 4.98±0.04 ^c | 4.59±0.02 ^{a^{bc}} |
| 6 | 4.76±0.02 ^{abcd} | 5.24±0.00 ^d | 4.57±0.06 ^{bc} | 4.32±0.64 ^{bc} | 4.69±0.02 ^{abcd} | 4.86±0.04 ^{cd} | 4.12±0.73 ^b | 3.49±0.13 ^a | 4.14±0.39 ^b |
| 9 | 4.63±0.15 ^{ab} | 5.08±0.24 ^b | 4.25±0.36 ^{ab} | 4.17±0.75 ^{ab} | 4.69±0.00 ^{ab} | 4.95±0.50 ^b | 3.68±1.05 ^a | 4.94±1.10 ^b | 4.19±0.22 ^{a^b} |
| 12 | 4.63±0.06 ^{abc} | 4.98±0.66 ^{bc} | 3.96±0.10 ^a | 4.18±0.69 ^{ab} | 3.77±0.79 ^a | 4.92±0.31 ^{bc} | 4.27±0.15 ^{ab} | 5.21±0.23 ^c | 4.49±0.59 ^{abc} |
| 15 | 4.90±0.58 ^b | 4.73±0.82 ^{ab} | 4.14±0.42 ^a | 4.56±0.01 ^{ab} | 4.69±0.02 ^{ab} | 5.11±0.22 ^b | 4.46±0.04 ^{ab} | 5.19±0.30 ^b | 4.74±0.17 ^{ab} |
| 18 | 5.32±0.05 ^b | 4.91±0.84 ^b | 3.90±0.24 ^a | 4.59±0.05 ^b | 4.77±0.06 ^b | 5.15±0.03 ^b | 4.64±0.09 ^b | 4.87±0.71 ^b | 4.89±0.02 ^b |
| 21 | 5.30±0.04 ^d | 3.87±0.43 ^a | 3.85±0.21 ^a | 4.65±0.03 ^{bc} | 4.76±0.17 ^c | 5.17±0.03 ^d | 4.29±0.40 ^b | 5.33±0.12 ^d | 5.38±0.24 ^d |
| 24 | 5.31±0.20 ^{ef} | 4.34±0.55 ^{bb} | 4.09±0.34 ^a | 4.68±0.04 ^{bc} | 4.82±0.08 ^{cd} | 5.08±0.02 ^{de} | 5.59±0.03 ^f | 5.43±0.03 ^{ef} | 5.17±0.20 ^{def} |
| 27 | 5.21±0.04 ^c | 4.15±0.45 ^a | 4.29±0.02 ^a | 4.71±0.04 ^b | 4.64±0.11 ^b | 5.17±0.07 ^c | 5.59±0.03 ^d | 5.41±0.05 ^{cd} | 5.52±0.01 ^{cd} |
| 30 | 5.21±0.02 ^c | 4.83±0.02 ^c | 4.37±0.03 ^a | 4.55±0.12 ^b | 4.43±0.09 ^a | 5.24±0.01 ^b | 5.49±0.12 ^c | 5.44±0.02 ^c | 5.41±0.06 ^c |
| 33 | 5.26±0.02 ^b | 4.76±0.07 ^{ab} | 4.40±0.01 ^a | 4.62±0.43 ^{ab} | 4.63±0.14 ^{ab} | 5.28±0.00 ^{bc} | 5.56±0.09 ^c | 4.82±1.08 ^{abc} | 5.29±0.15 ^{bc} |
| 36 | 3.56±0.61 ^a | 4.58±0.50 ^{bc} | 3.99±0.10 ^{ab} | 4.99±0.04 ^{cd} | 4.77±0.04 ^c | 5.01±0.04 ^{cd} | 5.60±0.07 ^d | 4.80±0.93 ^c | 4.78±0.02 ^c |
| 39 | 3.74±0.88 ^{ab} | 4.54±0.61 ^{bc} | 4.44±0.00 ^{ab} | 4.98±0.02 ^{cd} | 4.78±0.03 ^{bcd} | 5.03±0.03 ^{cd} | 5.68±0.00 ^d | 4.78±1.23 ^{bcd} | 3.48±0.44 ^a |
| 42 | 3.35±0.90 ^{ab} | 4.34±0.62 ^{abc} | 4.22±0.37 ^{abc} | 3.32±0.04 ^c | 4.72±1.10 ^c | 5.07±0.05 ^c | 5.05±1.11 ^c | 4.58±0.05 ^{bc} | 3.28±0.02 ^a |

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.17 Effect of nisin and pH on colour a* in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Colour a* | | | | | | | | |
|------------------------|---------------------------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|--------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 2.50±0.07 ^{ab} | 2.67±0.28 ^b | 2.20±0.33 ^{ab} | 1.99±0.18 ^a | 2.51±0.52 ^{ab} | 3.47±0.02 ^c | 2.31±0.17 ^{ab} | 2.15±0.36 ^{ab} | 2.17±0.49 ^{ab} |
| 3 | 2.81±0.41 ^c | 2.91±0.07 ^c | 2.16±0.03 ^b | 1.34±0.09 ^a | 1.96±0.04 ^b | 3.63±0.06 ^d | 2.18±0.08 ^b | 2.16±0.27 ^{ab} | 1.90±0.13 ^b |
| 6 | 2.29±0.49 ^c | 3.48±0.23 ^c | 2.74±0.07 ^d | 1.52±0.24 ^a | 1.88±0.03 ^{ab} | 1.89±0.02 ^{ab} | 2.17±0.04 ^{bc} | 1.67±0.02 ^a | 1.87±0.04 ^{ab} |
| 9 | 2.75±0.07 ^c | 3.41±0.04 ^f | 1.03±0.49 ^a | 1.38±0.11 ^{ab} | 1.98±0.50 ^d | 2.39±0.08 ^{bc} | 2.31±0.10 ^{cd} | 1.75±0.27 ^{bc} | 2.14±0.02 ^{bc} |
| 12 | 2.87±0.06 ^c | 3.46±0.4 ^f | 1.04±0.49 ^a | 1.41±1.11 ^{ab} | 2.34±0.49 ^d | 1.69±0.08 ^{bc} | 2.06±0.10 ^{cd} | 1.84±0.27 ^{bc} | 1.86±0.01 ^{bc} |
| 15 | 2.39±0.21 ^b | 2.47±0.74 ^b | 1.99±1.15 ^{ab} | 1.38±0.06 ^a | 1.90±0.02 ^{ab} | 1.71±0.04 ^{ab} | 2.19±0.20 ^{ab} | 1.68±0.01 ^{ab} | 2.15±0.47 ^{ab} |
| 18 | 2.48±0.36 ^{bc} | 2.39±0.45 ^b | 2.37±0.76 ^{bc} | 1.39±0.09 ^a | 2.25±0.57 ^{abc} | 2.70±0.86 ^c | 1.77±0.31 ^{abc} | 1.66±0.03 ^{ab} | 1.82±0.01 ^{abc} |
| 21 | 2.42±0.07 ^c | 3.52±0.02 ^d | 1.94±0.02 ^b | 1.34±0.06 ^a | 1.93±0.02 ^b | 2.42±0.70 ^c | 2.12±0.09 ^{bc} | 1.69±0.04 ^{ab} | 1.81±0.02 ^b |
| 24 | 2.63±0.16 ^d | 3.51±0.09 ^e | 2.35±0.54 ^{cd} | 1.29±0.03 ^a | 2.01±0.01 ^{bc} | 2.03±0.12 ^{bc} | 1.88±0.31 ^{bc} | 1.88±0.36 ^{bc} | 1.86±0.01 ^b |
| 27 | 2.47±0.34 ^{bc} | 3.61±0.06 ^d | 2.84±0.76 ^c | 1.55±0.68 ^a | 2.00±0.04 ^{ab} | 1.92±0.06 ^{ab} | 1.95±0.22 ^{ab} | 1.73±0.03 ^a | 1.81±0.02 ^{ab} |
| 30 | 2.73±0.47 ^{abcd} | 3.56±0.03 ^d | 2.17±0.82 ^{bc} | 1.84±0.45 ^{ab} | 2.03±0.00 ^{abc} | 1.86±0.01 ^{ab} | 2.19±0.42 ^{abc} | 1.71±0.02 ^a | 2.92±0.99 ^{cd} |
| 33 | 2.78±0.29 ^d | 3.60±0.03 ^f | 1.69±0.08 ^b | 1.49±0.01 ^a | 2.04±0.10 ^c | 1.89±0.04 ^{bc} | 1.70±0.03 ^b | 1.74±0.02 ^b | 2.48±0.04 ^e |
| 36 | 2.42±0.25 ^b | 3.62±0.04 ^c | 1.70±0.07 ^a | 1.88±0.42 ^a | 1.99±0.02 ^a | 1.92±0.02 ^a | 2.00±0.30 ^a | 1.73±0.06 ^a | 2.37±0.02 ^b |
| 39 | 2.33±0.04 ^c | 3.60±0.01 ^c | 3.69±0.31 ^c | 1.40±0.05 ^a | 1.95±0.02 ^{bc} | 2.17±0.44 ^{bc} | 2.06±0.03 ^{bc} | 1.75±0.02 ^{ab} | 3.10±0.51 ^c |
| 42 | 2.27±0.08 ^{bc} | 3.48±0.06 ^{de} | 1.99±0.48 ^{abc} | 1.41±0.04 ^{ab} | 2.35±0.66 ^c | 3.90±0.46 ^e | 2.07±0.35 ^{abc} | 1.18±1.02 ^a | 2.71±0.52 ^{cd} |

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.18 Effect of nisin and pH on colour b* in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Colour b* | | | | | | | | |
|---------------------|--------------------------|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|---------------------------|---------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 39.03±0.33 ^a | 39.47±0.17 ^{ab} | 38.67±1.10 ^a | 42.41±0.28 ^e | 42.57±0.31 ^e | 42.35±0.09 ^e | 41.76±0.71 ^{de} | 41.11±1.21 ^{cd} | 40.35±0.03 ^{bc} |
| 3 | 39.38±0.45 ^{bc} | 38.99±0.84 ^{ab} | 38.33±0.43 ^a | 41.12±0.09 ^e | 40.98±1.09 ^{de} | 39.61±0.14 ^{bc} | 42.2±0.05 ^f | 40.14±0.12 ^{cd} | 40.37±0.02 ^{cde} |
| 6 | 39.48±0.03 ^b | 39.09±0.43 ^b | 37.01±0.21 ^a | 40.82±0.13 ^d | 40.28±0.03 ^{cd} | 39.78±0.05 ^{bc} | 41.78±0.48 ^e | 39.07±0.36 ^b | 39.45±0.84 ^b |
| 9 | 41.14±0.13 ^{de} | 39.780.05 ^{bcd} | 36.78±0.37 ^a | 40.12±0.83 ^{cd} | 40.31±0.03 ^{cd} | 40.24±1.24 ^{cd} | 41.81±1.35 ^e | 39.35±1.09 ^{bc} | 38.57±0.18 ^b |
| 12 | 41.21±0.06 ^e | 39.55±0.71 ^d | 36.66±0.26 ^a | 39.93±0.48 ^d | 39.89±0.69 ^d | 37.750.08 ^b | 41.66±0.24 ^e | 40.21±0.14 ^d | 38.54±0.20 ^c |
| 15 | 40.73±0.95 ^{ef} | 39.26±1.12 ^{cd} | 36.69±0.30 ^a | 40.2±0.02 ^{de} | 40.71±0.06 st | 37.69±0.16 ^b | 41.38±0.06 ^f | 39.38±0.70 ^{cd} | 38.91±0.49 ^c |
| 18 | 41.21±0.08 ^f | 39.60±1.20 ^{cd} | 37.03±0.48 ^a | 40.15±0.05 ^{de} | 40.75±0.11 ^{ef} | 37.95±0.15 ^b | 41.18±1.12 ^e | 39.57±0.32 ^{cd} | 38.80±0.60 ^c |
| 21 | 41.23±0.06 ^g | 38.31±0.61 ^b | 36.72±0.03 ^{de} | 40.03±0.02 ^{de} | 40.66±0.02 ^{ef} | 38.19±0.20 ^b | 41.80±0.62 ^g | 39.59±0.17 ^{cd} | 39.18±0.87 ^c |
| 24 | 41.65±1.73 ^e | 38.95±0.54 ^{bc} | 36.06±1.46 ^a | 39.96±0.06 ^{cd} | 40.89±0.08 ^{de} | 38.69±0.09 ^{bc} | 39.05±0.03 ^{bc} | 39.66±0.01 ^{bed} | 38.22±0.08 ^b |
| 27 | 42.75±0.02 ^f | 38.79±0.80 ^{bc} | 36.80±0.05 ^a | 40.21±0.17 ^d | 40.99±0.05 ^e | 38.28±0.42 ^b | 39.04±0.04 ^c | 39.73±0.07 ^b | 38.79±0.06 ^{bc} |
| 30 | 42.79±0.06 ^g | 39.46±0.00 ^c | 36.40±0.13 ^c | 39.64±1.46 ^c | 39.83±1.02 ^c | 38.15±0.05 ^b | 38.90±0.15 ^{bc} | 39.57±0.03 ^c | 38.78±0.07 ^{bc} |
| 33 | 42.70±0.05 ^g | 39.05±1.09 ^{bc} | 36.53±0.08 ^a | 38.81±0.71 ^{bc} | 39.32±0.35 ^c | 38.29±0.02 ^b | 38.9±0.12 ^{bc} | 39.17±0.66 ^{bc} | 38.56±0.32 ^c |
| 36 | 41.51±1.14 ^e | 38.27±0.39 ^c | 37.24±0.28 ^b | 39.15±0.05 ^{cd} | 35.66±0.17 ^a | 38.86±0.32 ^{cd} | 39.37±0.27 ^d | 39.23±1.04 ^{cd} | 36.33±0.10 ^{ab} |
| 39 | 41.87±1.44 ^e | 38.19±0.60 ^{bed} | 37.18±0.04 ^{ab} | 39.19±0.03 ^d | 36.09±0.38 ^a | 38.84±0.03 ^{cd} | 39.31±0.07 ^d | 38.29±0.29 ^{bed} | 37.50±1.42 ^{bc} |
| 42 | 40.89±1.49 ^b | 37.61±0.67 ^{ab} | 37.23±0.05 ^{ab} | 26.15±0.05 ^{ab} | 35.2±4.86 ^a | 38.67±0.03 ^{ab} | 37.45±3.34 ^{ab} | 35.38±0.05 ^a | 37.15±0.25 ^{ab} |

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.19 Effect of nisin and pH on colour b* in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Colour b* | | | | | | | | |
|------------------------|--------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|--------------------------|---------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 45.52±0.05 ^{cd} | 45.04±1.01 ^{bc} | 45.88±0.22 ^{cd} | 44.12±0.68 ^{ab} | 43.1±1.01 ^a | 46.47±0.64 ^d | 44.11±0.19 ^{ab} | 43.50±0.79 ^a | 43.47±0.92 ^a |
| 3 | 46.07±0.11 ^c | 44.56±0.03 ^d | 46.05±0.6 ^c | 43.42±0.19 ^b | 42.9±0.11 ^a | 46.86±0.02 ^f | 43.99±0.09 ^c | 43.68±0.62 ^{bc} | 42.91±0.31 ^a |
| 6 | 46.17±0.43 ^b | 42.91±2.57 ^a | 46.32±0.24 ^b | 43.69±0.61 ^a | 42.79±0.01 ^a | 42.76±0.09 ^a | 44.01±0.05 ^a | 42.43±0.05 ^a | 42.71±0.05 ^a |
| 9 | 45.00±1.05 ^c | 44.35±0.03 ^{abc} | 43.59±1.80 ^{abc} | 43.250.09 ^{abc} | 42.97±0.23 ^{ab} | 44.47±1.54 ^{bc} | 44.17±0.03 ^{abc} | 42.62±0.54 ^a | 43.41±0.90 ^{abc} |
| 12 | 46.31±0.07 ^d | 44.36±0.02 ^c | 43.64±1.81 ^{abc} | 43.27±0.18 ^{abc} | 43.59±0.82 ^{abc} | 42.5±0.03 ^a | 43.92±0.18 ^{bc} | 42.89±0.65 ^{ab} | 42.79±0.03 ^{ab} |
| 15 | 45.32±0.14 ^c | 44.34±0.23 ^d | 45.43±1.17 ^c | 43.23±0.12 ^{abc} | 42.79±0.04 ^{ab} | 42.43±0.08 ^a | 43.95±0.08 ^{cd} | 42.47±0.03 ^a | 43.43±0.87 ^{bc} |
| 18 | 45.55±0.32 ^c | 44.52±0.13 ^{bc} | 44.45±2.10 ^{bc} | 43.29±0.21 ^{ab} | 43.39±0.96 ^{ab} | 44.14±1.39 ^{abc} | 42.92±0.78 ^{ab} | 42.45±0.10 ^a | 42.80.02 ^{ab} |
| 21 | 45.35±0.12 ^c | 44.18±0.01 ^d | 43.25±0.05 ^d | 43.19±0.15 ^{abc} | 42.77±0.02 ^{ab} | 43.5±1.25 ^{bcd} | 43.88±0.10 ^{cd} | 42.49±0.17 ^a | 42.82±0.02 ^{ab} |
| 24 | 45.86±0.14 ^d | 44.19±0.09 ^{bc} | 44.51±1.58 ^c | 43.09±0.03 ^{ab} | 42.82±0.02 ^a | 42.83±0.35 ^a | 43.17±0.66 ^{ab} | 42.9±0.87 ^a | 42.76±0.03 ^a |
| 27 | 45.75±0.26 ^d | 44.30±0.04 ^{bc} | 45.37±1.95 ^{cd} | 43.57±0.92 ^{ab} | 42.75±0.06 ^a | 42.63±0.11 ^a | 43.58±0.71 ^{ab} | 42.26±0.08 ^a | 42.73±0.02 ^a |
| 30 | 45.6±0.36 ^c | 44.30±0.03 ^{bc} | 44.00±2.42 ^{abc} | 43.79±0.78 ^{ab} | 42.71±0.04 ^{ab} | 42.53±0.05 ^{ab} | 43.65±0.09 ^{ab} | 42.25±0.06 ^a | 43.64±0.8 ^{ab} |
| 33 | 46.1±0.38 ^b | 44.35±0.02 ^b | 29.27±0.23 ^a | 43.09±0.03 ^{ab} | 42.83±0.18 ^{ab} | 42.69±0.15 ^{ab} | 42.45±0.13 ^{ab} | 42.23±0.09 ^{ab} | 42.8±0.12 ^{ab} |
| 36 | 46.13±0.16 ^c | 44.36±0.01 ^d | 42.59±0.18 ^{ab} | 43.88±0.77 ^{cd} | 42.73±0.04 ^{ab} | 42.67±0.10 ^{ab} | 43.33±0.09 ^{bc} | 42.27±0.08 ^a | 42.75±0.04 ^{ab} |
| 39 | 46.17±0.09 ^d | 44.35±0.02 ^c | 46.48±0.27 ^a | 43.08±0.04 ^{ab} | 42.78±0.05 ^{ab} | 43.49±1.47 ^{bc} | 43.83±0.05 ^{bc} | 42.24±0.06 ^a | 43.68±1.04 ^{bc} |
| 42 | 46.15±0.09 ^b | 44.26±0.06 ^b | 44.88±2.04 ^b | 43.10±0.08 ^{ab} | 43.31±0.99 ^{ab} | 44.88±0.15 ^b | 43.28±0.82 ^{ab} | 28.15±0.24 ^a | 43.29±0.90 ^{ab} |

Values are means ± standard deviations for triplicate measurements
 Values followed by different letters are significantly different ($p < 0.05$).

Table A4.20 Effect of nisin and pH on total soluble solids in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Total soluble solids (%) | | | | | | | | |
|------------------------|--------------------------|--------------|--------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 11.93±0.06 | 11.93±0.06 | 11.93±0.06 | 11.93±0.06 | 11.93±0.06 | 11.93±0.06 | 11.93±0.06 | 11.93±0.06 | 11.93±0.06 |
| 3 | 11.90±0.10 | 11.77±0.10 | 11.80±0.10 | 11.70±0.06 | 11.83±0.06 | 11.80±0.10 | 11.83±0.06 | 11.83±0.06 | 11.7±0.20 |
| 6 | 11.80±0.10 | 11.73±0.20 | 11.80±0.10 | 11.70±0.10 | 11.83±0.06 | 11.73±0.30 | 11.60±0.30 | 11.80±0.10 | 11.67±0.30 |
| 9 | 8.07±0.06 | 6.57±0.21 | 5.87±0.06 | 10.50±0.10 | 10.57±0.10 | 10.67±0.06 | 10.50±0.00 | 10.63±0.06 | 10.37±0.06 |
| 12 | 7.23±0.25 | 6.53±0.23 | 5.83±0.12 | 10.50±0.10 | 10.50±0.10 | 10.27±0.31 | 10.50±0.00 | 10.60±0.00 | 10.17±0.06 |
| 15 | 6.47±0.06 | 6.40±0.00 | 5.80±0.17 | 10.50±0.10 | 10.47±0.06 | 9.73±0.11 | 10.43±0.06 | 10.23±0.06 | 10.00±0.00 |
| 18 | 5.30±0.10 | 6.33±0.06 | 5.73±0.06 | 10.13±0.12 | 9.67±0.15 | 8.73±0.21 | 10.33±0.06 | 10.13±0.06 | 9.33±0.42 |
| 21 | 5.33±0.06 | 4.77±0.23 | 5.67±0.06 | 10.07±0.21 | 7.53±0.35 | 7.57±0.35 | 10.00±0.17 | 9.40±0.10 | 8.90±0.00 |
| 24 | 4.40±0.20 | 4.00±0.00 | 3.90±0.00 | 9.97±0.06 | 7.30±0.52 | 7.57±0.15 | 9.80±0.26 | 8.67±0.15 | 7.47±0.06 |
| 27 | 4.40±0.20 | 4.00±0.00 | 3.87±0.06 | 8.63±0.38 | 7.10±0.10 | 7.53±0.06 | 7.40±0.10 | 7.40±0.44 | 7.40±0.00 |
| 30 | 4.40±0.20 | 3.87±0.06 | 3.30±0.26 | 7.27±0.21 | 7.10±0.10 | 7.20±0.20 | 7.40±0.10 | 7.10±0.00 | 6.97±0.06 |
| 33 | 4.40±0.15 | 3.83±0.00 | 3.43±0.01 | 7.23±0.11 | 6.03±0.01 | 6.53±0.49 | 7.40±0.10 | 6.90±0.06 | 6.70±0.23 |
| 36 | 4.47±0.20 | 3.80±0.06 | 3.20±0.06 | 6.83±0.25 | 5.80±0.06 | 5.67±0.06 | 7.40±0.10 | 6.73±0.00 | 6.37±0.00 |
| 39 | 4.10±0.00 | 3.80±0.00 | 3.20±0.01 | 6.50±0.00 | 5.13±0.23 | 5.00±0.00 | 6.90±0.00 | 6.10±0.10 | 5.80±0.10 |
| 42 | 4.10±0.00 | 3.80±0.00 | 3.17±0.15 | 6.00±0.00 | 5.07±0.06 | 5.00±0.10 | 5.90±0.36 | 5.77±0.23 | 5.30±0.10 |

Values are means ± standard deviations for triplicate measurements
 Values followed by different letters are significantly different ($p < 0.05$).

Table A4.21 Effect of nisin and pH on total soluble solids in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Total soluble solids (%) | | | | | | | | |
|---------------------|---------------------------|-------------------------|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 11.43±0.05 | 11.60±0.20 | 11.43±0.05 | 11.47±0.05 | 11.47±0.05 | 11.47±0.11 | 11.47±0.05 | 11.47±0.05 | 11.47±0.05 |
| 3 | 11.43±0.05 ^{ab} | 11.60±0.20 ^b | 11.43±0.05 ^{ab} | 11.47±0.05 ^{ab} | 11.33±0.15 ^a | 11.47±0.11 ^{ab} | 11.37±0.05 ^a | 11.30±0.10 ^a | 11.43±0.05 ^{ab} |
| 6 | 11.43±0.05 ^{abc} | 11.60±0.20 ^c | 11.43±0.05 ^{abc} | 11.47±0.05 ^{bc} | 11.33±0.15 ^{ab} | 11.47±0.11 ^{bc} | 11.20±0.10 ^b | 11.27±0.15 ^{ab} | 11.33±0.15 ^{ab} |
| 9 | 10.60±0.01 ^e | 5.70±0.20 ^a | 6.77±0.05 ^b | 11.37±0.05 ^b | 10.87±0.15 ^f | 11.10±0.17 ^f | 10.20±0.26 ^d | 9.87±0.05 ^c | 10.50±0.10 ^e |
| 12 | 10.43±0.25 ^d | 5.60±0.26 ^a | 6.67±0.06 ^b | 11.27±0.15 ^f | 10.87±0.15 ^f | 10.33±0.15 ^d | 10.20±0.26 ^d | 9.80±0.10 ^c | 10.50±0.10 ^d |
| 15 | 10.37±0.28 ^{ab} | 5.60±0.26 ^a | 5.37±0.15 ^a | 10.53±0.28 ^{ab} | 10.80±0.26 ^{ab} | 10.33±0.15 ^{ab} | 10.20±0.26 ^{ab} | 9.80±0.10 ^{ab} | 9.83±0.29 ^{ab} |
| 18 | 10.10±0.01 ^d | 5.60±0.26 ^a | 5.37±0.15 ^a | 10.77±0.15 ^e | 10.53±0.06 ^e | 9.47±0.15 ^b | 10.20±0.26 ^d | 9.80±0.10 ^c | 9.20±0.20 ^b |
| 21 | 9.87±0.15 ^d | 5.50±0.36 ^a | 5.37±0.15 ^a | 10.20±0.10 ^e | 9.80±0.10 ^d | 8.63±0.83 ^c | 8.53±0.25 ^e | 8.37±0.32 ^e | 7.40±0.10 ^b |
| 24 | 8.10±0.10 | 5.37±0.15 | 5.37±0.15 | 8.07±0.06 ^f | 6.30±0.10 | 2.72±0.10 | 8.47±0.35 | 7.60±0.10 | 7.13±0.15 |
| 27 | 7.40±0.10 ^e | 5.10±0.10 ^a | 5.37±0.15 ^b | 8.07±0.06 ^f | 5.40±0.26 ^b | 6.40±0.10 ^e | 6.93±0.15 ^d | 7.47±0.06 ^e | 6.93±0.15 ^d |
| 30 | 6.30±0.10 ^c | 5.03±0.06 ^a | 5.37±0.15 ^b | 7.20±0.30 ^e | 5.00±0.01 ^a | 6.37±0.15 ^{cd} | 5.40±0.01 ^b | 6.50±0.01 ^{cd} | 6.60±0.01 ^d |
| 33 | 6.27±0.06 ^f | 4.80±0.01 ^{ab} | 5.00±0.01 ^{bc} | 5.50±0.20 ^e | 5.00±0.01 ^{bc} | 6.40±0.10 ^f | 4.63±0.11 ^a | 5.23±0.21 ^{cd} | 5.33±0.15 ^d |
| 36 | 5.33±0.15 ^{de} | 3.63±0.15 ^a | 5.00±0.10 ^{cd} | 5.50±0.20 ^e | 4.67±0.58 ^c | 6.40±0.10 ^f | 4.63±0.11 ^c | 3.80±0.01 ^{ab} | 4.10±0.10 ^b |
| 39 | 4.30±0.10 ^c | 3.57±0.06 ^a | 4.63±0.06 ^{de} | 5.50±0.20 ^f | 4.80±0.01 ^e | 4.17±0.15 ^{bc} | 4.57±0.12 ^d | 3.73±0.06 ^a | 4.00±0.00 ^b |
| 42 | 3.90±0.10 ^{bc} | 3.47±0.06 ^a | 3.67±0.15 ^{ab} | 5.50±0.20 ^f | 4.57±0.49 ^e | 4.17±0.15 ^{cd} | 4.40±0.10 ^d | 3.67±0.06 ^{ab} | 3.60±0.26 ^a |

Values are means ± standard deviations for triplicate measurements
 Values followed by different letters are significantly different ($p < 0.05$).

Table A4.22 Effect of nisin and pH on reducing sugar in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Reducing sugar (mg/100g) | | | | | | | | |
|------------------------|--------------------------|--------------|--------------|---------------|---------------|------------------------|-------------------------|-------------------------|-------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 2.89±0.06 | 2.86±0.06 | 2.90±0.06 | 2.89±0.06 | 2.85±0.06 | 2.85±0.06 | 2.85±0.05 | 2.85±0.05 | 2.85±0.056 |
| 3 | 2.85±0.08 | 2.81±0.08 | 2.89±0.08 | 2.81±0.06 | 2.77±0.07 | 2.84±0.07 | 2.75±0.45 | 2.79±0.05 | 2.74±0.03 |
| 6 | 2.87±0.04 | 2.81±0.04 | 2.89±0.03 | 2.81±0.03 | 2.77±0.03 | 2.84±0.03 | 2.75±0.03 | 2.79±0.03 | 2.74±0.03 |
| 9 | 2.20±0.24 | 1.95±0.30 | 1.70±0.30 | 2.65±0.23 | 2.47±0.00 | 2.36±0.20 ^a | 2.49±0.47 ^{cd} | 2.45±0.76 ^{bc} | 1.65±0.03 ^b |
| 12 | ND | ND | ND | 2.65±0.23 | 2.47±0.28 | 2.36±0.20 ^b | 2.49±0.47 ^f | 2.45±0.57 ^{de} | 1.65±0.57 ^{cd} |
| 15 | ND | ND | ND | 2.57±0.22 | 2.47±0.28 | 1.42±0.13 ^b | 2.49±0.47 ^e | 2.45±0.57 ^e | 1.65±0.18 ^{bc} |
| 18 | ND | ND | ND | 2.57±0.23 | 2.36±0.28 | 1.42±0.13 ^b | 1.78±0.14 ^d | 1.74±0.05 ^b | 1.33±0.18 ^c |
| 21 | ND | ND | ND | 2.05±0.32 | 1.54±0.21 | 1.10±0.13 ^b | 1.79±0.14 ^c | 1.44±0.15 ^b | 1.04±0.18 ^b |
| 24 | ND | ND | ND | 1.70±0.33 | 1.06±0.21 | ND | 1.42±0.13 | 1.36±0.18 | ND |
| 27 | ND | ND | ND | 1.48±0.16 | ND | ND | 1.42±0.03 | ND | ND |
| 30 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different (p < 0.05).

Table A4.23 Effect of nisin and pH on reducing sugar in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Reducing sugar (mg/100g) | | | | | | | | |
|------------------------|--------------------------|--------------|--------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 3.57±0.03 | 3.56±0.08 | 3.56±0.04 | 3.56±0.03 | 3.56±0.08 | 3.58±0.09 | 3.56±0.08 | 3.56±0.08 | 3.56±0.09 |
| 3 | 3.55±0.06 | 3.52±0.08 | 3.41±0.04 | 3.56±0.02 | 3.51±0.05 | 3.26±0.08 | 3.46±0.08 | 3.50±0.10 | 3.54±0.16 |
| 6 | 3.55±0.06 | 3.52±0.08 | 3.41±0.04 | 3.27±0.02 | 3.51±0.06 | 3.26±0.08 | 3.46±0.08 | 3.43±0.10 | 3.47±0.16 |
| 9 | 3.02±0.24 | 3.32±0.24 | 3.02±0.00 | 3.27±0.12 | 3.45±0.32 | 1.94±0.21 | 3.41±0.17 | 2.93±0.26 | 2.57±0.28 |
| 12 | ND | ND | ND | 3.27±0.12 | 2.23±0.32 | 1.94±0.22 | 3.41±0.16 | 2.82±0.26 | 2.57±0.28 |
| 15 | ND | ND | ND | 3.27±0.04 | 2.23±0.32 | 1.42±0.13 | 3.41±0.16 | 2.82±0.26 | 1.78±0.28 |
| 18 | ND | ND | ND | 3.27±0.04 | 2.23±0.22 | 1.42±0.13 | 2.34±0.30 | 2.17±0.22 | 1.78±0.11 |
| 21 | ND | ND | ND | 2.40±0.05 | 2.19±0.08 | 1.04±0.13 | 2.34±0.14 | 1.96±0.01 | 1.10±0.28 |
| 24 | ND | ND | ND | 2.40±0.33 | 1.72±0.08 | ND | 1.98±0.12 | 1.06±0.01 | ND |
| 27 | ND | ND | ND | 1.80±0.16 | ND | ND | 1.23±0.16 | ND | ND |
| 30 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.24 Effect of nisin and pH on ascorbic acid in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Ascorbic acid (mg/100g) | | | | | | | | |
|---------------------|--------------------------|-------------------------|---------------------------|---------------------------|--------------------------|---------------------------|---------------------------|--------------------------|--------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 28.87±0.35 | 28.87±0.35 | 28.87±0.35 | 28.60±0.79 | 28.60±0.79 | 28.60±0.79 | 28.60±0.79 | 28.60±0.79 | 28.60±0.79 |
| 3 | 28.13±0.40 ^{bc} | 25.63±0.25 ^a | 26.90±0.00 ^{abc} | 27.33±0.76 ^{abc} | 26.17±1.33 ^{ab} | 26.80±1.56 ^{abc} | 28.63±0.46 ^{abc} | 28.10±0.69 ^{bc} | 26.57±2.02 ^{ab} |
| 6 | 28.13±0.40 ^b | 25.63±0.25 ^a | 25.33±1.43 ^a | 27.33±0.76 ^b | 25.63±0.25 ^a | 25.93±0.90 ^a | 28.27±0.21 ^b | 25.30±0.66 ^a | 25.50±0.46 ^a |
| 9 | 3.13±0.40 ^b | 2.63±0.25 ^a | 2.33±1.43 ^a | 17.93±0.76 ^b | 12.43±0.25 ^a | 11.83±0.09 ^a | 18.43±0.21 ^b | 11.30±0.66 ^a | 11.30±0.46 ^a |
| 12 | ND | ND | ND | 9.57±1.59 | 9.21±1.59 | 9.04±1.59 | 9.70±2.02 | 9.10±2.02 | 9.10±0.79 |
| 15 | ND | ND | ND | 9.57±1.59 | 9.04±0.21 | 9.04±0.21 | 9.27±2.02 | 9.04±2.02 | 9.04±2.02 |
| 18 | ND | ND | ND | 9.57±1.59 | 6.63±0.25 | 2.43±0.79 | 7.63±0.25 | 6.41±2.02 | 2.55±0.02 |
| 21 | ND | ND | ND | 7.93±1.59 | 3.07±1.59 | ND | 5.55±2.02 | 3.43±2.02 | ND |
| 24 | ND | ND | ND | 4.17±0.35 | ND | ND | 3.93±0.35 | ND | ND |
| 27 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 30 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.25 Effect of nisin and pH on ascorbic acid in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Ascorbic acid (mg/100g) | | | | | | | | |
|------------------------|--------------------------|---------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------|-------------------------|---------------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 27.27±0.92 ^a | 27.27±0.92 ^a | 27.27±0.92 ^a | 27.27±0.92 ^a | 27.27±0.92 ^a | 27.27±0.92 ^a | 28.50±0.00 ^a | 27.27±0.92 ^a | 27.27±0.92 ^a |
| 3 | 27.27±0.92 ^{cd} | 26.00±0.17 ^{abc} | 25.40±1.14 ^{ab} | 27.17±0.47 ^{cd} | 26.83±0.95 ^{bc} | 25.97±0.95 ^{bc} | 28.50±0.00 ^d | 25.27±0.81 ^a | 26.47±0.96 ^{abc} |
| 6 | 27.13±0.83 ^{cd} | 25.47±0.51 ^{ab} | 25.13±1.17 ^a | 27.17±0.47 ^d | 25.40±1.31 ^{ab} | 25.97±0.95 ^{ac} | 28.27±0.21 ^a | 25.10±0.70 ^a | 26.80±0.62 ^{bcd} |
| 9 | ND | ND | ND | 22.30±2.11 | 13.30±3.80 | 11.53±2.49 | 15.23±3.1 | 10.70±1.73 | 10.70±1.73 |
| 12 | ND | ND | ND | 15.00±3.58 | 10.70±1.31 | 9.27±0.21 | 10.17±1.31 | 10.42±0.81 | 10.70±1.31 |
| 15 | ND | ND | ND | 11.53±0.58 | 9.21±0.30 | 6.41±0.21 | 9.04±0.51 | 8.83±0.11 | 5.55±0.11 |
| 18 | ND | ND | ND | 11.53±0.58 | 2.87±0.30 | 2.07±0.21 | 6.41±0.21 | 5.27±0.21 | 1.93±0.21 |
| 21 | ND | ND | ND | 4.17±0.46 | 2.87±0.30 | ND | 3.47±0.21 | 2.43±0.21 | ND |
| 24 | ND | ND | ND | 3.87±0.17 | ND | ND | 3.47±0.21 | ND | ND |
| 27 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 30 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Values are means ± standard deviations for triplicate measurements

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.26 Effect of nisin and pH on total plate count in orange juice cv. Sai Num Pung during storage at 4°C

| Storage time (days) | TPC(CFU/ml) | | | | | | | | |
|------------------------|-----------------------|----------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | 3.8×10^2 | 3.7×10^2 | 3.7×10^2 | 3.3×10^2 | 3.3×10^2 | 3.3×10^2 | 3.3×10^2 | 3.3×10^2 | 3.3×10^2 |
| 3 | 6.0×10^{2d} | 5.5×10^{2c} | 6.0×10^{2d} | 3.4×10^{2a} | 3.9×10^{2b} | 4.1×10^{2b} | 3.3×10^{2a} | 3.2×10^{2a} | 3.3×10^{2a} |
| 6 | 6.0×10^{2f} | 8.6×10^{2g} | 9.9×10^{2g} | 3.5×10^{2a} | 5.5×10^{2e} | 6.5×10^{2g} | 4.3×10^{2b} | 4.8×10^{2c} | 5.2×10^{2d} |
| 9 | 1.1×10^{6a} | 2×10^{6b} | 2.7×10^{6c} | 9.9×10^{2a} | 1.3×10^{3a} | 1.8×10^{2b} | 9.5×10^{2a} | 1.2×10^{3a} | 1.2×10^{3a} |
| 12 | 2.2×10^{6b} | 2.2×10^{6b} | 2.7×10^{6c} | 1.1×10^{3a} | 1.8×10^{3b} | 1.8×10^{3b} | 1.2×10^{3a} | 1.2×10^{3a} | 1.9×10^{3b} |
| 15 | 2.3×10^{6c} | 3.3×10^{6d} | 3.2×10^{6d} | 1.1×10^{3a} | 2.4×10^{3c} | 1.9×10^{3c} | 1.7×10^{3b} | 2.3×10^{3c} | 2.5×10^{3c} |
| 18 | 2.7×10^{6bc} | 4.2×10^{6d} | 5.3×10^{6e} | 1.5×10^{3a} | 2.4×10^{3b} | 1.9×10^{3bc} | 1.8×10^{3a} | 2.5×10^{3bc} | 2.8×10^{3c} |
| 21 | 2.3×10^{6e} | 4.2×10^{6d} | 5.3×10^{6g} | 1.8×10^{3a} | 2.4×10^{3b} | 3.0×10^{6de} | 2.6×10^{3bc} | 2.8×10^{3cd} | 4.4×10^{6f} |
| 24 | 4.4×10^{6d} | 4.2×10^{6d} | 5.3×10^{6e} | 2.2×10^{3a} | 3.1×10^{6bc} | 3.2×10^{6c} | 2.8×10^{3b} | 3.3×10^{6c} | 5.1×10^{6e} |
| 27 | 4.7×10^{6cd} | 6×10^{6e} | 7.7×10^{6f} | 2.7×10^{6a} | 3.1×10^{6ab} | 4.4×10^{6c} | 3.5×10^{6b} | 4.7×10^{6cd} | 5.2×10^{6d} |
| 30 | 4.9×10^{6ab} | 6×10^{6e} | 7.7×10^{6d} | 4.6×10^{6a} | 5.2×10^{6ab} | 5.6×10^{6bc} | 5.4×10^{6bc} | 7.2×10^{6d} | 8.3×10^{6c} |
| 33 | 7.0×10^{6cd} | 9.5×10^{6f} | 1.1×10^{6g} | 4.6×10^{6a} | 5.2×10^{6ab} | 6.1×10^{6bc} | 5.4×10^{6ab} | 7.4×10^{6de} | 8.3×10^{6d} |
| 36 | 7.3×10^{6b} | 1.0×10^{7c} | 1.4×10^{6d} | 4.6×10^{6a} | 5.2×10^{6a} | 7.8×10^{6b} | 8.2×10^{6b} | 7.9×10^{6b} | 8.3×10^{6b} |
| 39 | 1.3×10^{7d} | 1.6×10^{7c} | 2.0×10^{7f} | 5.2×10^{6a} | 7.4×10^{6b} | 7.7×10^{6bc} | 8.2×10^{6b} | 9.2×10^{6bc} | 1.0×10^{7c} |
| 42 | 2.4×10^{7de} | 2.7×10^{7e} | 2.2×10^{7c} | 5.2×10^{6a} | 1.4×10^{7b} | 1.2×10^{7c} | 8.2×10^{6a} | 1.7×10^{7bc} | 2.0×10^{7ed} |

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.27 Effect of nisin and pH on total plate count in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | TPC(CFU/ml) | | | | | | | | |
|------------------------|-----------------------|----------------------|-----------------------|-----------------------|-----------------------|------------------------|----------------------|-----------------------|-----------------------|
| | 1 (0,3,6) | 2 (0,4,2) | 3 (0,4,8) | 4 (50,3,6) | 5 (50,4,2) | 6 (50,4,8) | 7 (100,3,6) | 8 (100,4,2) | 9 (100,4,8) |
| 0 | 4.1×10 ^{2b} | 4.1×10 ^{2b} | 4.1×10 ^{2b} | 3.2×10 ^{2a} | 3.2×10 ^{2a} | 3.2×10 ^{2a} | 3.2×10 ^{2a} | 3.2×10 ^{2a} | 3.2×10 ^{2a} |
| 3 | 4.6×10 ^{2d} | 6.4×10 ^{2c} | 7.4×10 ^{2f} | 2.9×10 ^{2a} | 3.5×10 ^{2b} | 3.6×10 ^{2b} | 3.7×10 ^{2b} | 8.8×10 ^{2cb} | 4.1×10 ^{2c} |
| 6 | 5.2×10 ^{2c} | 7.2×10 ^{2e} | 9.3×10 ^{2f} | 4.6×10 ^{2b} | 5.2×10 ^{2c} | 6.5×10 ^{2a} | 4.2×10 ^{2a} | 5.2×10 ^{2c} | 6.4×10 ^{2d} |
| 9 | 1.1×10 ^{6a} | 1.5×10 ^{6b} | 1.9×10 ^{6c} | 1.1×10 ^{3a} | 1.8×10 ^{3c} | 1.9×10 ^{3c} | 1.4×10 ^{3b} | 1.8×10 ^{3c} | 2.3×10 ^{3d} |
| 12 | 1.7×10 ^{6c} | 1.7×10 ^{6c} | 2.1×10 ^{6d} | 1.1×10 ^{3a} | 2.5×10 ^{3c} | 2.8×10 ^{3f} | 1.4×10 ^{3b} | 1.8×10 ^{3c} | 3.2×10 ^{3g} |
| 15 | 2.7×10 ^{6cd} | 3.3×10 ^{6f} | 4.5×10 ^{6g} | 2.2×10 ^{3c} | 2.5×10 ^{3d} | 2.8×10 ^{3c} | 1.4×10 ^{3a} | 1.8×10 ^{3b} | 3.2×10 ^{3f} |
| 18 | 2.7×10 ^{6de} | 5.1×10 ^{6g} | 5.3×10 ^{6g} | 2.2×10 ^{3c} | 2.5×10 ^{3d} | 2.8×10 ^{3c} | 1.4×10 ^{3a} | 1.9×10 ^{3b} | 3.2×10 ^{3f} |
| 21 | 2.7×10 ^{6e} | 5.2×10 ^{6e} | 5.3×10 ^{6e} | 2.2×10 ^{3b} | 2.5×10 ^{3c} | 2.8×10 ^{3c} | 1.4×10 ^{3a} | 2.4×10 ^{3bc} | 4.3×10 ^{6d} |
| 24 | 2.7×10 ^{6e} | 5.2×10 ^{6g} | 5.3×10 ^{6g} | 2.4×10 ^{3b} | 3.2×10 ^{6d} | 4.4×10 ^{6f} | 1.9×10 ^{3a} | 7.5×10 ^{6e} | 4.3×10 ^{6f} |
| 27 | 4.2×10 ^{6cd} | 5.2×10 ^{6g} | 6.1×10 ^{6f} | 3.6×10 ^{6a} | 3.8×10 ^{6bc} | 4.7×10 ^{6e} | 3.3×10 ^{6a} | 3.8×10 ^{6bc} | 4.3×10 ^{6de} |
| 30 | 5.6×10 ^{6b} | 7.5×10 ^{6d} | 8.1×10 ^{6c} | 4.2×10 ^{6a} | 5.3×10 ^{6b} | 6.7×10 ^{6c} | 3.8×10 ^{6a} | 3.8×10 ^{6a} | 6.9×10 ^{6c} |
| 33 | 6.0×10 ^{6c} | 7.5×10 ^{6e} | 8.1×10 ^{6f} | 4.2×10 ^{6a} | 6.3×10 ^{6cd} | 8.1×10 ^{6f} | 4.8×10 ^{6b} | 6.6×10 ^{6d} | 8.2×10 ^{6f} |
| 36 | 6.1×10 ^{6b} | 7.5×10 ^{6d} | 8.1×10 ^{6e} | 5.4×10 ^{6a} | 6.8×10 ^{6c} | 8.1×10 ^{6e} | 6.8×10 ^{6b} | 8.1×10 ^{6c} | 9.8×10 ^{6f} |
| 39 | 1.2×10 ^{6cd} | 1.1×10 ⁷ | 1.3×10 ^{7cd} | 8.3×10 ^{6ab} | 9.6×10 ^{6bc} | 1.1×10 ^{6bcd} | 6.3×10 ^{6a} | 9.6×10 ^{6bc} | 1.3×10 ^{6d} |
| 42 | 2.5×10 ⁷ | 2.5×10 ⁷ | 2.7×10 ⁷ | 8.3×10 ⁶ | 1.7×10 ⁷ | 1.9×10 ⁷ | 8.5×10 ⁷ | 1.6×10 ⁷ | 2.1×10 ⁷ |

ND = not detectable

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.28 Effect of nisin and pH on yeast and mould in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Yeast and mould (CFU/ml) | | | | | | | | |
|---------------------|--------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 3 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 6 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 9 | 3.7×10 ² | 6.1×10 ² | 9.0×10 ² | <10 | <10 | <10 | <10 | <10 | <10 |
| 12 | 4.5×10 ⁴ | 7.2×10 ⁴ | 1.2×10 ⁵ | <10 | <10 | <10 | <10 | <10 | <10 |
| 15 | 5.6×10 ⁵ | 1.1×10 ⁶ | 1.9×10 ⁶ | <10 | <10 | <10 | <10 | <10 | <10 |
| 18 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 21 | ND | ND | ND | <10 | <10 | 1.1×10 ² | <10 | <10 | <10 |
| 24 | ND | ND | ND | <10 | <10 | 1.7×10 ³ | <10 | 9.0×10 ² | 1.5×10 ³ |
| 27 | ND | ND | ND | 5.0×10 ² | 1.3×10 ³ | 2.0×10 ⁴ | 7.2×10 ² | 9.0×10 ³ | 1.8×10 ³ |
| 30 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Values followed by different letters are significantly different (p < 0.05).

Table A4.29 Effect of nisin and pH on yeast and mould in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Yeast and Mould (CFU/ml) | | | | | | | | |
|------------------------|--------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 3 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 6 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 9 | 5.6×10^2 | 5.5×10^2 | 6.5×10^2 | <10 | <10 | <10 | <10 | <10 | <10 |
| 12 | 6.5×10^4 | 6.1×10^4 | 9.0×10^5 | <10 | <10 | <10 | <10 | <10 | <10 |
| 15 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 18 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 21 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 24 | ND | ND | ND | <10 | <10 | 1.0×10^2 | <10 | <10 | 8.0×10^2 |
| 27 | ND | ND | ND | <10 | 1.1×10^2 | 1.1×10^2 | <10 | 7.0×10^2 | 1.2×10^3 |
| 30 | ND | ND | ND | 9.0×10^2 | 1.3×10^3 | 1.1×10^3 | 6.0×10^2 | 1.2×10^3 | 1.2×10^3 |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.30 Effect of nisin and pH on lactic acid bacteria in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Lactic acid bacteria (CFU/ml) | | | | | | | | |
|------------------------|-------------------------------|-------------------|-------------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 3 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 6 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 9 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 12 | 4.4×10^3 | 5.1×10^3 | 5.3×10^3 | <10 | <10 | <10 | <10 | <10 | <10 |
| 15 | 6.2×10^3 | 6.9×10^3 | 7.9×10^3 | <10 | <10 | <10 | <10 | <10 | <10 |
| 18 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 21 | ND | ND | ND | <10 | <10 | <30 | <10 | <10 | <30 |
| 24 | ND | ND | ND | <10 | <30 | <30 | <10 | <30 | <30 |
| 27 | ND | ND | ND | <30 | <30 | <30 | <30 | <30 | <30 |
| 30 | ND | ND | ND | <30 | <30 | <30 | <30 | <30 | <30 |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Table A4.31 Effect of nisin and pH on lactic acid bacteria in orange juice cv. Khieo Waan during storage at 4°C

| Storage time (days) | Lactic acid bacteria (CFU/ml) | | | | | | | | |
|------------------------|-------------------------------|-------------------|-------------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | 1 (0,3.6) | 2 (0,4.2) | 3 (0,4.8) | 4 (50,3.6) | 5 (50,4.2) | 6 (50,4.8) | 7 (100,3.6) | 8 (100,4.2) | 9 (100,4.8) |
| 0 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 3 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 6 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 9 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 12 | 5.2×10^3 | 7.4×10^3 | 8.3×10^3 | <10 | <10 | <10 | <10 | <10 | <10 |
| 15 | 7.7×10^3 | 9.5×10^3 | 9.5×10^3 | <10 | <10 | <10 | <10 | <10 | <10 |
| 18 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 21 | ND | ND | ND | <10 | <10 | <30 | <10 | <10 | <10 |
| 24 | ND | ND | ND | <10 | <30 | <30 | <10 | <10 | <30 |
| 27 | ND | ND | ND | <30 | <30 | <30 | <10 | <30 | <30 |
| 30 | ND | ND | ND | <30 | <30 | <30 | <30 | <30 | <30 |
| 33 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Table A4.32 Effect of nisin and pH on spore count in orange juice cv. Sai Nam Pung during storage at 4°C

| Storage time (days) | Spore count (CFU/ml) | | | | | | | | |
|------------------------|----------------------|--------------|--------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | 1 (0,3,6) | 2 (0,4,2) | 3 (0,4,8) | 4 (50,3,6) | 5 (50,4,2) | 6 (50,4,8) | 7 (100,3,6) | 8 (100,4,2) | 9 (100,4,8) |
| 0 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 3 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 6 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 9 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 12 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 15 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 18 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 21 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 24 | ND | ND | ND | <10 | <10 | <30 | <10 | <10 | <30 |
| 27 | ND | ND | ND | <10 | <30 | <30 | <10 | <30 | <30 |
| 30 | ND | ND | ND | <30 | <30 | <30 | <30 | <30 | <30 |
| 33 | ND | ND | ND | ND | ND | ND | <30 | <30 | <30 |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Table A4.33 Effect of nisin and pH on spore count in orange juice cv. Khieo Wann during storage at 4°C

| Storage time (days) | Spore count (CFU/ml) | | | | | | | | |
|------------------------|----------------------|--------------|--------------|---------------|---------------|---------------|----------------|----------------|----------------|
| | 1 (0,3,6) | 2 (0,4,2) | 3 (0,4,8) | 4 (50,3,6) | 5 (50,4,2) | 6 (50,4,8) | 7 (100,3,6) | 8 (100,4,2) | 9 (100,4,8) |
| 0 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 3 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 6 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| 9 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 12 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 15 | <30 | <30 | <30 | <10 | <10 | <10 | <10 | <10 | <10 |
| 18 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 21 | ND | ND | ND | <10 | <10 | <10 | <10 | <10 | <10 |
| 24 | ND | ND | ND | <10 | <10 | <30 | <10 | <10 | <30 |
| 27 | ND | ND | ND | <30 | <30 | <30 | <10 | <30 | <30 |
| 30 | ND | ND | ND | <30 | <30 | <30 | <30 | <30 | <30 |
| 33 | ND | ND | ND | ND | ND | ND | <30 | <30 | <30 |
| 36 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 39 | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 42 | ND | ND | ND | ND | ND | ND | ND | ND | ND |

ND = not detectable

Table A4.34 Sensory properties of orange juice cv. Sai Nam Pung during storage at 6 days

| Treatment (nisin, pH) | Appearance | Colour | Odour | Turbidity | Sweet | Sour | Overall |
|--------------------------|------------|--------|-------|-----------|---------|------|---------|
| 1 (0, 3.6) | 4.00 a | 5.80a | 6.70 | 6.60 ab | 5.05 b | 7.10 | 4.65 a |
| 2 (0, 4.2) | 4.85 a | 5.90a | 6.75 | 6.60 ab | 4.20 a | 6.85 | 4.80 a |
| 3 (0, 4.8) | 4.45 a | 6.55ab | 6.75 | 7.00 b | 5.10 b | 7.35 | 6.05 b |
| 4 (50, 3.6) | 7.50 c | 7.10b | 7.25 | 6.95 ab | 7.65 d | 8.15 | 7.50 c |
| 5 (50, 4.2) | 6.55 bc | 7.25b | 7.25 | 6.40 ab | 7.00 cd | 6.80 | 7.55 c |
| 6 (50, 4.8) | 6.85 bc | 6.75ab | 7.15 | 6.30 ab | 6.95 cd | 6.50 | 7.35 c |
| 7 (100, 3.6) | 7.40 c | 6.90b | 7.15 | 6.40 ab | 6.95 cd | 6.70 | 7.25 c |
| 8 (100, 4.2) | 6.60 bc | 7.40b | 7.10 | 6.65 ab | 7.10 cd | 6.75 | 7.60 c |
| 9 (100, 4.8) | 6.15 b | 7.05b | 6.95 | 6.15 a | 6.70 c | 6.50 | 7.00 c |
| LSD _{0.05} | * | * | ns | * | * | ns | * |

Values are means

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.35 Sensory properties of orange juice cv. Khieo wann during storage at 6 days

| Treatment (nisin, pH) | Appearance | Colour | Odour | Turbidity | Sweet | Sour | Overall |
|--------------------------|------------|--------|-------|-----------|-------|--------|---------|
| 1 (0, 3.6) | 7.40 | 7.55 | 7.10 | 7.35 | 7.10 | 7.55 b | 5.65 a |
| 2 (0, 4.2) | 7.10 | 7.00 | 7.10 | 7.35 | 7.35 | 7.70 b | 5.95 ab |
| 3 (0, 4.8) | 7.20 | 7.20 | 6.90 | 6.95 | 7.30 | 7.60 b | 6.00 ab |
| 4 (50, 3.6) | 6.65 | 6.95 | 7.10 | 7.05 | 7.15 | 6.65 a | 7.85 c |
| 5 (50, 4.2) | 6.60 | 7.30 | 6.45 | 7.25 | 7.00 | 6.55 a | 6.65 b |
| 6 (50, 4.8) | 6.80 | 6.80 | 7.00 | 7.55 | 6.95 | 6.35 a | 6.80 b |
| 7 (100, 3.6) | 7.40 | 7.35 | 7.15 | 6.80 | 6.95 | 6.70 a | 8.00 c |
| 8 (100, 4.2) | 7.35 | 7.50 | 7.10 | 7.00 | 7.10 | 6.40 a | 6.60 b |
| 9 (100, 4.8) | 6.75 | 6.75 | 6.40 | 6.75 | 6.70 | 6.50 a | 6.75 b |
| LSD _{0.05} | ns | ns | ns | ns | ns | * | * |

Values are means

Values followed by different letters are significantly different ($p < 0.05$).

Table A4.36 Sensory properties of orange juice cv. Sai Nam Pung during storage at 18 days

| Treatment (nisin, pH) | Appearance | Colour | Odour | Turbidity | Sweet | Sour | Overall |
|--------------------------|------------|---------|---------|-----------|---------|---------|---------|
| 4 (50, 3.6) | 7.55 c | 8.25 d | 7.20 b | 7.20 | 6.20 bc | 7.85 c | 720 bc |
| 5 (50, 4.2) | 6.40 b | 7.15 bc | 6.75 ab | 6.60 | 6.35 bc | 6.95 b | 6.55 b |
| 6 (50, 4.8) | 5.25 a | 6.20 a | 6.45 a | 6.25 | 5.10 a | 6.15 ab | 5.30 a |
| 7 (100, 3.6) | 8.25 c | 7.80 cd | 7.10 b | 6.90 | 6.45 bc | 7.95 c | 6.90 bc |
| 8 (100, 4.2) | 6.45 b | 7.25 bc | 7.25 b | 6.40 | 7.00 c | 6.80 b | 7.55 c |
| 9 (100, 4.8) | 5.85 ab | 6.55 ab | 6.35 a | 6.20 | 5.80 ab | 5.50 a | 5.60 a |
| LSD _{0.05} | * | * | * | ns | * | * | * |

Values are means

Values followed by different letters are significantly different ($p < 0.05$).


Table A4.37 Sensory properties of orange juice cv. Khieo Wann during storage at 18 days

| Treatment (nisin, pH) | Appearance | Colour | Odour | Turbidity | Sweet | Sour | Overall |
|--------------------------|------------|---------|-------|-----------|---------|---------|---------|
| 4 (50, 3.6) | 7.60 b | 8.05 b | 6.80 | 6.95 ab | 7.20 c | 8.10 c | 6.60 b |
| 5 (50, 4.2) | 6.90 b | 6.75 a | 7.20 | 7.20 b | 6.80 bc | 6.70 ab | 6.90 b |
| 6 (50, 4.8) | 5.35 a | 6.95 a | 7.05 | 6.70 ab | 6.15 ab | 6.10 a | 5.40 a |
| 7 (100, 3.6) | 7.25 b | 7.45 ab | 7.35 | 6.75 ab | 6.85 bc | 7.25 bc | 6.65 b |
| 8 (100, 4.2) | 6.75 b | 6.85 a | 6.95 | 6.60 ab | 7.55 c | 6.35 ab | 7.10 b |
| 9 (100, 4.8) | 5.70 a | 6.85 a | 6.75 | 6.25 a | 5.50 a | 5.75 a | 5.15 a |
| LSD _{0.05} | * | * | ns | * | * | * | * |

Values are means

Values followed by different letters are significantly different ($p < 0.05$).

VITA



| | |
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