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Effect of Nan golden orange juice on manufacturing process and characterization of processed cheese during storage

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Abstract The separately acidified with citric acid solution presented a soft set curd and had the highest yield of 72.00±1.53%. The prepared soft cheese was then mixed with milk and butter to produce the cheese blend. Nan golden (NG) orange juice was fortified with different ratios (0,10,20,30,40 and 50%) to cheese blend. NG orange juice was able added up to 50%. The appearance of NG orange juice-cheese blend was uniformly with yellow-orange tone color. Corn starch (5,10 and 15%) was added to make a firmer texture. The optimized addition of corn starch was 5 % due to creating a smooth surface. The improvement of processed cheese texture was studied by using carrageenan (0,0.6,0.8,1 and 1.2%). The use of carrageenan at 0.8% improved the hardness, cohesiveness, gumminess, and chewiness of product. The NG orange juice-cheese can be stored at 4^{o}C for 14 days without microbial qualities changes.

Keywords: Carrageenan, Cheese, Citric acid, Orange

Introduction

Geographical Indication (GI) is a sign that represents products have a specific geographical origin, a unique characteristic of quality and reputation. “Nan Golden Orange” or “Som Si Thong Nan” is one of GI products in Thailand. It is mandarin orange variety which grown in Nan province. Its uniqueness is thin golden peel, low fiber in pulps, not juicy, round and fat shape with hollow spots at the upper and lower cores with sweet and sour taste. The golden orange gets specific color only from growing in Nan because the huge temperature difference within a day has turned the color of carotenoid pigment in oranges’ peels from green into gold. (Department of Intellectual Property, 2019).

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Nan Golden (NG) Orange is now commercially grown for fresh and processed consumption. Orange juice is a natural source of sugars, vitamins, minerals, phenolic compounds, flavanones and is associated with a healthy diet (Rapisarda *et al*., 1999). A mandarin orange contains water 85%, carbohydrates 13%, and negligible amounts of fat and protein. Vitamin C (ascorbic acid) is found in significant amounts in the fruits of several mandarin cultivars, ranging from 150 to 500 mg/L juice (Marti *et al*., 2009). Orange juice is an ingredient in products like fruit preparations, fillings, toppings, and confectionery products. Various local products from NG orange have been developed includes pasteurized juice, jams, jelly, cookies, and cakes.

Consumer interest in healthy foods and beverages has increased over the last decade. There are many functional products made from fruit juices and dairy products in order to add nutraceutical components from fruits to products such as fruit juice dairy blends (Adebayo-Oyetoro *et al*., 2016), yoghurt with different fruit juice (Hossain *et al*., 2012) and ricotta cheese whey-fruit juice beverages (Cortellino *et al.,* 2007; Rizzolo and Cortellino, 2018).

Cheese can be produced using enzyme (rennet) and organic acids (citric acid, acetic acid, and others) (Rashidinejad *et al*., 2017). Cottage cheese and ricotta cheese are white, fresh, not aged, and shapeless cheeses. Cottage cheese is a soft uncured cheese, lactic acid or enzyme is added in order to coagulate protein in milk and separate the curd from the whey. Cottage cheese can be made using skim-milk or whole milk. Ricotta is high-moisture unripened cheese obtained by direct acidification of milk or whey (Hough *et al*., 1999). Ricotta cheese is a light, smooth and creamy cheese with a gentle texture. The type of coagulant is one of the most relevant processing factors in ricotta cheese production. Lactic acid, acetic acid, citric acid are acidulants are added to reduce the pH and induce coagulation of proteins. Weatherup (1986) found that citric acid produced better ricotta than acetic acid.

Natural cheese refers to cheese that is made directly from milk. Processed cheese is made using natural cheese mix with other ingredients that are melted together to improve textural and sensory properties or produced it in a form that is convenient for consumption and extending shelf life. The addition of bioactive compounds in processed cheese could affect not only the taste but also the consistent quality (Kapoor *et al*., 2008). Processed cheese is basically produced in four steps, including size reduction, blending, heating, and packaging (Ozturk and Kilic-Akyilmaz, 2022).

The aims were to produce functional processed cheese cube with Nan golden orange juice and to investigate effects of golden orange juice on production and characterization of orange cheese cube during storage.

Materials and methods

Nan golden (NG) oranges were harvested from Thung Chang District, Nan, Province, Thailand. Whole raw cow's milk was purchased from local market near Thammasat University, Thailand. Pasteurized milk (CP-Meiji Co., Ltd.) and butter (The Thai Dairy Industry Co., Ltd.) were purchased from a supermarket. Citric acid and carrageenan were obtained from Chemipan Corporation Co., Ltd., Thailand. Rennet was procured from The Junket Folks, Denmark. Corn starch was purchased from Unilever Thai Trading Co., Ltd., Thailand.

Juice and coagulants preparation

To prepare the juice, NG oranges were washed, cut in half crosswise and then removed seeds. Oranges were squeezed by using a juicer machine (K76, Moulinex, Thailand). Squeezed NG orange juice was sieved, packed, and refrigerated at 4 ^{o}C until use. The juice will be used as a coagulant and an ingredient in soft cheese preparation and cheese blend production, respectively. The 10% w/v citric acid solution was prepared for being a coagulant.

Soft cheese preparation

Citric acid solution, rennet and NG orange juice were used as coagulant agents in soft cheese making. For each treatment, 1 kg of whole raw cow's milk was poured in a stainless-steel pot and warmed up to 35 ^{o}C and then coagulant was added. Four types of coagulants were used including 1) Acid coagulant; 50 g of 10% citric solution 2) Rennet enzyme; 0.005% rennet 3) Acid-rennet combination; 50 g of 10% citric solution and 0.005% rennet and 4) NG orange juice; 50 g of NG orange juice. After each type of coagulant was added in warmed milk, all treatments were stirred gently for few minutes. The coagulated curd mass was left in the whey for 10 mins and then scooped it into cheesecloth and hanged for 15 mins to drain whey. The obtained soft curds in chessclothes were placed over a drainage table and allow to achieve complete drainage at room temperature for 60 mins. The soft cheese was then transferred to cube silicone mold for curd setting and kept in refrigerator overnight. All products were photographed. The soft cheeses were weighed. Th pH of soft cheese samples derived from different coagulants were determined and the percentage of yield were calculated as follow equation (1)

$$\%\text{yield} = \frac{\text{Weight of soft cheese obtained (g)}}{\text{Weight of whole raw cow's milk used (g)}} \text{x}100 \qquad (1)$$

Juice-cheese blend production

The ingredients in cheese blend making were a selected soft cheese, pasteurized milk, butter, and NG orange juice. 90 g of soft cheese was mixed with 15 g of pasteurized milk and 30 g of butter by using a high-speed blender for 1 min. The blend was mixed with various content of NG orange juice. The ratio of cheese blend to NG orange juice were 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50, respectively. All blend products were photographed. The color values (L*, a* and b*), total soluble solid (^{o}Brix) and pH of all formulas were investigated.

Processed cheese formation

Corn starch is used as a thickening agent which can increase the viscosity of liquid, decrease syneresis and improve firmness. In order to transform the juice-cheese blend to a solid cheese structure, the addition of corn starch was studied. The NG orange juice-cheese blend was added with corn starch at 5, 10, 15% of total weight. Then, the mixtures were heated to 85 ^{o}C and held for 5 minutes in order to pasteurize. The orange juice-cheese mixture was poured into a heat-resistant 4x4x4 cm cube silicone mold and refrigerated at 4 ^{o}C for 8 hours. For color value (L*, a* and b*) and texture profile analysis of NG orange juice-cheese, cubic samples of 2 cm edge were cut and used. All products were photographed. The color and texture profile analysis of cheese cubes were examined.

Improvement of texture

To improve the texture of curd cheese, the use of carrageenan in foods is considered safe and has a positive effect on texture (Li *et al.*, 2014). NG orange juice-cheese was improved its texture properties by adding carrageenan at 0, 0.8, 1 and 1.2% of total weight. All ingredients were prepared and mixed well before pasteurization and formation. Processed cheese products were photographed. The texture profile analysis of cheese cube was measured.

Quality determination

Chemical quality: Chemical qualities were determined following; total soluble solid content (^{o}brix), pH, water activity (a_w) and proximate

composition. Total soluble solid was measured by a refractometer (HI96801, Hanna, Romania). The pH values were detected by using a pH meter (PB-20, Satorius, Germany). Water activity (a_w) values of products were determined by a water activity meter (AQUA LAB, CX2, USA). Proximate composition analysis; Fat, protein, sodium, vitamin B_2, calcium and iron were analyzed according to in-house method based on AOAC (2019). Total energy and carbohydrate were analyzed according to method of analysis for nutrition labeling by Central Laboratory (Thailand) Co., Ltd. Total phenolic in NG orange juice - cheese product was determined by using Folin-Ciocalteu reagent and was calculated by a standard curve prepared with Gallic acid. Total phenolic was expressed as µg GAE/g sample (El-Said *et al*., 2012).

Physical quality: Color values (L*, a* and b*) were determined by using a colorimeter (CX2678, Hunter Lab, USA). NG orange juice-cheese was cut to 2 cm thickness and measured its texture by using a texture analyzer (plus-upgrade, Stable Micro System, USA). The hardness, springiness, cohesiveness, chewiness, adhesiveness, and gumminess of cheese cube samples were analyzed by double compressing using 50 mm (P/50) cylinder probe under following condition: pre-test speed:1.00 mm/s, test-speed:1.00 mm/s, post speed: 1.00 mm/s.

Microbiological analyses: Total plate count (FDA-BAM, 2001), *Bacillus cereus* (ISO7932:2004), *Listeria monocytogenes* (ISO6888-1:1999), *Staphylococcus aureus* (ISO6888-1:1999), *Salmonella* spp. (ISO6579-1:2017), yeast and molds; 3M Petrifilm, AOAC Official Method^{SM} 997.02 (3M Food Safety, 2016) were analyzed by Asia Medical and Agricultural Laboratory and Research Center Public Company Limited, Thailand.

Refrigerated storage study

Plastic boxes containing 100 g of NG orange juice-cheese cube were stored in a refrigerator at temperature of 4 ^{o}C. The processed cheeses were examined color value (L*, a* and b*), pH, a_w every 2 days within 14 days. Analyses of microorganism level was conducted at 0, 7 and 14 days storage. Change in color over time was calculated as ΔE, ΔE was the total color difference and was used to compare any change in color over time. ΔE was calculated follow the equation (2)

$$\Delta E = [(L_f^*-L_i^*)^2+(a_f^*-a_i^*)^2+(b_f^*-b_i^*)^2]^{\wedge}½ \qquad (2)$$

Where L_i*, a_i* and b_i* were the initial values at day 0. L_f*, a_f* and b_f* were the values obtained each time the samples were analyzed.

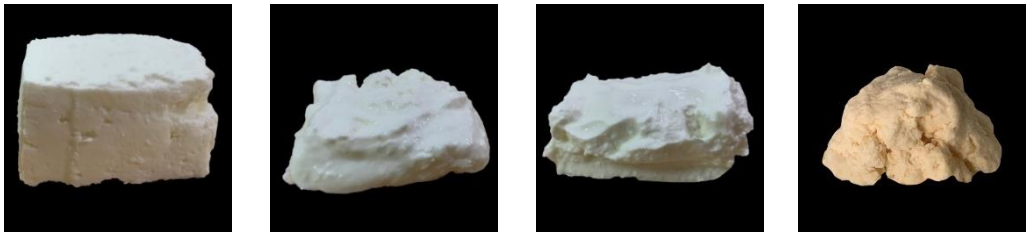
Statistical analysis

A completely randomized design was used, and differences among group means were analyzed by Duncan's new multiple range test ($p<0.05$). All the measurements were carried out in triplicate, except for texture profile analysis, which was replicated 10 times.

Results

Soft cheese preparation

Result showed photographs of soft cheese samples coagulated by citric acid solution (a), rennet (b), citric acid solution plus rennet (c) and NG orange juice (d) (Figure 1). It was noticed that the appearance of soft cheeses made from acid solution, rennet and a mix of acid and rennet were white, except soft cheese clotted by juice coagulant which was light orange caused by the color of carotenoids from orange juice. Only cheese coagulated by citric acid solution had a settle shape.



(a) (b) (c) (d)

Figure 1. Soft cheeses made from citric acid solution (a), rennet (b) citric acid solution plus rennet (c) and NG orange juice (d)

The pH values and yield percentages of soft cheese made from different coagulants are presented in Table 1. The pH of soft cheese prepared with citric acid solution, a combination of citric acid solution and rennet, and NG orange juice were in the range of 4.00-4.70. Soft cheese was produced by rennet resulting in neutral pH at 7.0. The highest yield was obtained in soft cheese curd by acidifying milk with an aqueous acidulant, which was 72.00$\pm$1.53 %. The milk coagulation with citric acid solution was selected to prepare soft cheese.

Table 1. Effect of coagulants on pH and yield of soft cheeses

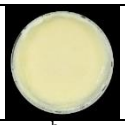
Coagulants	Citric acid solution	Rennet	Citric acid solution + rennet	NG Orange juice
pH	$4.70^{b1/}\pm0.01$	$7.00^{a}\pm0.01$	$4.70^{b}\pm0.02$	$4.00^{c}\pm0.02$
%Yield	$72.00^{a}\pm1.53$	$51.39^{c}\pm0.58$	$62.12^{b}\pm1.32$	$36.70^{d}\pm1.32$

[1] Different letters in the same row indicates that values are significantly different ($p<0.05$).

Juice-cheese blend production

The effect of different blend ratios of soft cheese and NG orange juice on color values of juice-cheese blend products are shown in Table 2. The appearance of cheese blend samples without juice added was milky white. The color tended to be more yellowish caused by the adding higher amount of orange juice. This result was in accordance with the color measurement. The redness (a*) and yellowness (b*) increased, while the lightness (L*) decreased with the increasing of NG orange juice level.

Table 2. Color values (L*, a* and b*) of cheese blend mixed with NG orange juice at various ratios

	Cheese blend: NG orange juice					
	100:0	90:10	80:20	70:30	60:40	50:50
Samples						
L*	$89.67^{a1/}\pm0.02$	$88.24^{b}\pm0.03$	$83.30^{c}\pm0.19$	$82.91^{d}\pm0.19$	$82.23^{e}\pm0.06$	$80.76^{f}\pm0.01$
a*	$-1.00^{f}\pm0.01$	$0.83^{e}\pm0.01$	$3.57^{d}\pm0.04$	$4.95^{c}\pm0.04$	$5.83^{b}\pm0.04$	$8.02^{a}\pm0.02$
b*	$12.35^{f}\pm0.01$	$17.65^{e}\pm0.03$	$17.41^{d}\pm0.15$	$19.38^{c}\pm0.08$	$21.40^{b}\pm0.05$	$24.85^{a}\pm0.02$

[1] Different letters in the same row indicates that values are significantly different ($p< 0.05$).

Total soluble solid and pH values of cheese blend mixed with NG orange juice are shown in Table 3. The increase of NG orange juice content resulted in the rising of total soluble solid, while reduction in pH occurred. In this study the maximum added of NG orange juice was 50%. At this addition percentage, the blends were very much fortified with functional compounds and nutrients from NG orange juice with homogeneous appearance blend.

Processed cheese formation

Photos and the values of lightness, redness and yellowness of processed cheese samples showed in Table 4. The look of all samples was cube shape although these cubes were not perfect shaped. The firmer structure could be noticed. All structure look settles after filling corn starch. For color, the

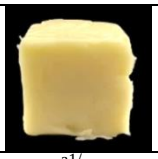
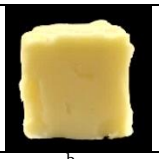
brightness, redness and yellowness of three samples were in the range of 49.00 – 54.23, 2.94 – 3.45 and 24.74 – 26.27, respectively. The addition of corn starch to processed cheese caused change in L*, a* and b* significantly ($p<0.05$).

Table 3. Total soluble solid and pH of cheese blend mixed with NG orange juice at various ratio

Cheese blend: NG orange juice	TSS (^{o}brix)	pH
100:0	$8.53^{b1/} \pm 0.31$	$4.77^{a} \pm 0.06$
90:10	$8.53^{b} \pm 0.15$	$4.73^{a} \pm 0.06$
80:20	$8.77^{ab} \pm 0.46$	$4.63^{ab} \pm 0.06$
70:30	$9.33^{ab} \pm 1.31$	$4.57^{b} \pm 0.06$
60:40	$9.30^{ab} \pm 0.87$	$4.53^{b} \pm 0.05$
50:50	$9.93^{a} \pm 0.06$	$4.53^{b} \pm 0.06$

[1] Different letters in the same column indicates that values are significantly different ($p< 0.05$).

Table 4. Color values (L*, a* and b*) of NG orange juice-processed cheese cube added 3 levels of corn flour

Samples	Corn flour (%)		
	5	10	15
			
L*	$54.23^{a1/} \pm 0.07$	$51.85^{b} \pm 1.27$	$49.00^{c} \pm 0.13$
a*	$3.45^{a} \pm 0.02$	$3.26^{b} \pm 0.12$	$2.94^{c} \pm 0.02$
b*	$25.20^{bc} \pm 0.14$	$24.74^{c} \pm 0.36$	$27.26^{a} \pm 0.10$

[1] Different letters in the same row indicates that values are significantly different ($p< 0.05$).

Texture profile analysis of processed cheese fortified with NG orange juice when adding 3 levels of corn starch was examined and reported in Table 5. The results demonstrate that the addition of polysaccharide to juice-cheese curd increased hardness, adhesiveness, cohesiveness, gumminess, chewiness values in finished products, while springiness were inclined to decrease significantly ($p<0.05$). It can be noticed that hardness, gumminess and chewiness values of 5% to 15% corn starch addition rise significantly around 2.5-3 times. The optimized addition of corn starch was 5 % due to creating a smooth surface and no cracking.

Improvement of texture

Result revealed the effect of carrageenan on texture profiles of juice-processed cheese (Table 6). The texture characteristics of juice-cheese in part of

hardness, cohesiveness, gumminess, and chewiness increased when the rising of carrageenan content was applied, even though springiness decreased. The highest hardness, cohesiveness, gumminess, and chewiness values were found in sample added 1.2% carrageenan.

Table 5. Texture profile analysis of of NG orange juice-processed cheese cube added 3 levels of corn flour

Corn flour (%)	Hardness ($g_{.force}$)	Adhesiveness (g.sec)	Springiness	Cohesiveness	Gumminess ($g_{.force}$)	Chewiness ($g_{.force}$)
5	$338.84^{c1/}\pm59.55$	$-62.46^{a}\pm40.47$	$0.72^{a}\pm0.06$	$0.40^{a}\pm0.06$	$133.09^{c}\pm16.55$	$88.23^{b}\pm19.62$
10	$646.16^{b}\pm96.59$	$-50.75^{b}\pm32.46$	$0.66^{b}\pm0.12$	$0.44^{a}\pm0.04$	$284.14^{b}\pm43.09$	$205.26^{a}\pm57.92$
15	$796.77^{a}\pm84.51$	$-41.22^{c}\pm25.52$	$0.65^{b}\pm0.07$	$0.44^{a}\pm0.03$	$352.79^{a}\pm39.29$	$231.57^{a}\pm42.35$

[1] Different letters in the same column indicates that values are significantly different ($p< 0.05$).

Table 6. Texture profiles of juice-processed cheese changed due to carrageenan

Carrageenan (%)	Hardness ($g_{.force}$)	Adhesiveness (g.sec)	Springiness	Cohesiveness	Gumminess ($g_{.force}$)	Chewiness ($g_{.force}$)
0	$320.52^{d1/}\pm38.64$	$-50.15^{a}\pm6.78$	$0.63^{a}\pm0.12$	$0.38^{d}\pm0.09$	$140.66^{d}\pm9.84$	$92.31^{d}\pm5.02$
0.8	$732.55^{c}\pm26.53$	$-36.54^{b}\pm13.52$	$0.43^{b}\pm0.22$	$0.54^{c}\pm0.11$	$233.45^{c}\pm7.53$	$235.41^{c}\pm23.42$
1	$896.41^{b}\pm33.48$	$-30.21^{c}\pm8.41$	$0.38^{c}\pm0.14$	$0.72^{b}\pm0.52$	$246.25^{b}\pm8.54$	$386.12^{b}\pm15.66$
1.2	$946.54^{a}\pm24.55$	$-25.14^{d}\pm7.32$	$0.30^{d}\pm0.24$	$0.81^{a}\pm0.61$	$259.04^{a}\pm10.12$	$450.22^{a}\pm8.65$

[1] Different letters in the same column indicates that values are significantly different ($p< 0.05$).

Chemical composition of functional processed cheese is shown in Table 7. NG orange-cheese cube 100 g contained 21.71 g of fat, 7.52 g of protein, 18.61 g of carbohydrate and 379.74 g of sodium. In addition, NG orange-cheese cube also provided vitamin A 271.88 μg RE/100 g, vitamin B_2 0.11 mg/100 g, vitamin C 10.64 mg/100 g, calcium 106.67 mg/100 g, iron 2.38 mg/100 g and phenolic 77.79±0.01 μg GAE/g sample.

Table 7. Chemical composition of orange cheese cube product

Chemical composition	Content
Total energy (kcal)	299.91±0.05
Total fat (g/100g)	21.71±0.02
Protein (g/100g)	7.52±0.03
Fiber (g/100g)	2.80±0.02
Carbohydrate (g/100g)	18.61±0.02
Sodium (mg/100g)	379.74±0.02
Vitamin A (μg RE/100g)/1	271.88±0.01
Vitamin B2 (mg/100g)	0.11±0.03
Vitamin C (mg/100g)	10.64±0.01
Calcium (mg/100g)	106.67±0.01
Iron (mg/100g)	2.38±0.02
Phenolic (μg GAE/g sample)	77.79±0.01

[1] RE = retinol equivalents (The total vitamin A content of a food is usually expressed as micrograms (μg) of retinol equivalents because the age range has different retinol needs.

Shelf-life study

The appearance of NG orange-cheese pieces was still in the cube shape during 2 weeks cold storage without any collapse or cracking in Figure 2.

(a) (b) (c) (d) (e) (f) (g) (h)

Figure 2. Photographs of NG orange-cheese cube stored at 4^{o}C for 0 (a), 2 (b), 4 (c), 6 (d), 8 (e), 10 (f), 12 (g) and 14 (h) days

The values of color, pH and a_w of NG orange-cheese cube product during storage at 4^{o}C for 14 days are shown in Table 8 and Figure 3. The results presented that during 14 days storage, NG orange-cheese cube had brightness (L*), redness (a*) and yellowness (b*) in the range of 83.00–85.67, 6.33–7.67, 37.67–41.00, respectively. The ΔE value of sample increased slightly from 1.28 to 2.63 within 2 weeks. The pH value and a_w were 4.48–4.53 and 0.883–0.890, respectively.

Table 8. Color values (L*, a*, b* and ΔE) of orange cheese cube stored at 4^{o}C for 14 days

Day	L*$^{ns1/}$	a*^{ns}	b*	ΔE
0	84.33±0.58	7.67±1.53	40.67$^{a2/}$±1.53	-
2	83.78±1.02	6.99±0.64	39.33^{a}±0.33	1.28^{f}±0.21
4	85.33±1.53	6.57±0.25	39.67^{a}±0.25	1.61^{d}±0.05
6	85.40±0.98	6.50±1.76	39.98^{a}±1.10	1.49^{e}±0.10
8	85.67±0.58	6.67±0.85	39.67^{a}±0.58	1.90^{c}±0.19
10	85.52±0.95	6.45±0.50	39.54^{a}±0.74	2.10^{b}±0.08
12	85.33±0.58	6.40±0.03	39.04^{ab}±0.65	2.63^{a}±0.25
14	83.32±0.55	7.67±1.53	38.72^{b}±2.33	2.50^{a}±0.11

[1] non-significant ($p \geq 0.05$), [2]Different letters in the same column indicates that values are significantly different ($p < 0.05$).

Result showed the number of microorganisms found in NG orange-cheese product stored at 4^{o}C for 14 days (Table 9). Total plate count, *Bacillus cereus*, *Staphylococcus aureus*, and yeast and molds count were found to be less than 10 CFU/g, and *Listeria monocytogenes* and *Salmonella* spp. were not detected in the 25 g sample.

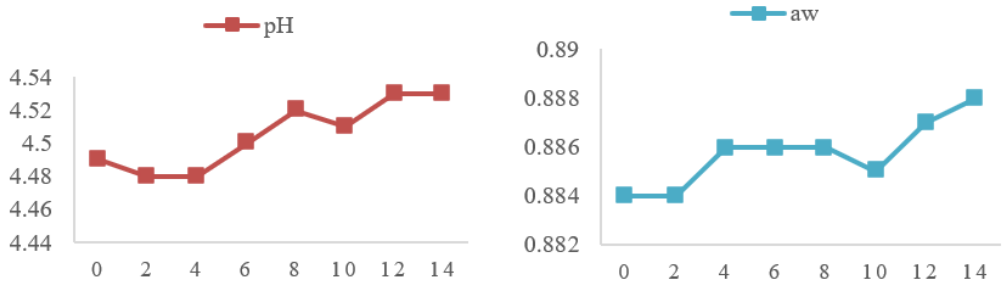


Figure 4. pH and a_w of orange cheese cube stored at 4°C for 14 days

Table 9. Microorganism of NG orange-cheese product stored at 4°C for 14 days

Microorganism	Days		
	0	7	14
Total plate count (CFU/g)	<10	<10	<10
Bacillus cereus (CFU/g)	<10	<10	<10
Listeria monocytogenes (CFU/25 g)	Not detected	Not detected	Not detected
Staphylococcus aureus (CFU/g)	<10	<10	<10
Salmonella spp. (CFU/25 g)	Not detected	Not detected	Not detected
Yeast and molds count (CFU/g)	<10	<10	<10

Dicussion

Soft cheese preparation

Soft cheese derived from 10% citric acid solution had the highest yield percentage followed by soft cheese made from citric acid combined with rennet, which were 72.00±1.53 and 62.12±1.32% respectively. This is because soft cheese made from citric acid solution and citric acid solution combined with rennet had pH of 4.7. Whole raw cow's milk contains casein and it is precipitated from whole cow's raw milk at pH 4.6 (Siamand and Al-Saadi, 2017). Soft cheese from rennet had pH of 7.00 and yield percentage of 51.39±0.58. At pH higher than 5.0, calcium is greater soluble and decreases protein-to-protein interactions (Pastorino *et al*., 2003). Soft cheese made from squeezed NG orange juice had the lowest yield percentage and pH, which was 36.70±1.32% and 4.00±0.02. The explanation is that cheese with too low pH (< 4.6) appear too grainy texture (Phadungath, 2005) and caseins are too few interactions (Johnson, 2000). This may be the cause of the loss of yield in the

filtering stage. Therefore, citric acid solution was chosen as a coagulant because it provided the highest quality and yield of soft cheese.

Juice-cheese blend production

The addition of NG orange juice in cheese blend resulted in an increase of yellow color tone of the cream cheese. According to Kale *et al.* (2011) reported that adding orange juice to soy milk caused the product had darker orange color. Adding orange juice to cream cheese tended to rise total soluble solid while the pH value of cream cheese tended to decline. The addition of acidic fruit to dairy products leaded to lower pH in milk (Abbasi and Mohammadi, 2013). The addition of NG orange juice in the propotion of 50% were selected. Because it was the maximum amount in this study that could be put in the mixture and did not affect the quality.

Processed cheese formation

Corn starch was added to juice-cheese blend to form a cube shape. The addition of corn starch brought about a stronger texture. This is because the gelling of the starch improves stability of cheese structure (Seesung, 2020). Corn starch contains approximately 29% amylose (Supajai, 2008), which amylose causes the stronger network and corresponds to the cohesiveness and adhesion values. These values describe the adhesion or binding within the cheese structure which attends to increase as the amount of corn starch increases. The addition of corn starch at 10 and 15% provide hard and cracked texture. This may be due to the addition of too much starch, causing insufficient water in the system to absorb and gelling. Thus, the addition of corn starch at 5% was enough to formed a cube shape.

Improvement of texture

Processed cheese was modified formation with corn starch however its texture was not firm properly. Carrageenan normally is used to promote slicing ability and increase firmness of cream cheese (Błaszak *et al*., 2018). In this study, the addition of carrageenan resulted in the increase values of hardness, adhesiveness, cohesiveness, gumminess, and chewiness, whereas the springiness values tended to decrease. This is because carrageenan can bind water and form gel structures (Popescu *et al*., 2007). According to the report of Kim *et al.* (2018), the addition of carrageenan in meat products increased hardness, adhesion, cohesiveness, and chewiness, while springiness decreased.

However, the addition of carrageenan up to 1-1.2% of total weight effected cracking in cheese because high amount of carrageenan was able to promote more rigid structure (Błaszak *et al*., 2018). Therefore, the texture improvement of NG orange juice-processed cheese cube by using 0.8% of carrageenan was suitable proportion due to this content had an increasing effect on hardness and chewiness values and had the least effect on reducing springiness of processed cheese cube product.

Chemical composition

Cheese is a good source of essential nutrients, such as proteins, lipids, minerals, and vitamins (Kwak *et al*., 2015). The nutrition of NG orange juice-processed cheese cube contained fat, protein, carbohydrate, and micronutrients such as calcium and iron. Moreover, the addition of NG orange juice was fortified vitamin C, vitamin A and phenolic supplement to create functional cheese. The development of this new cheese is value-added dairy product with local GI fruit that can promote both product and place of plant origin for customers.

Shelf-life study

The processed cheese fortified with NG orange juice product could maintain a cube shape and the separation of the water or syneresis did not occur. A sightly increasing of pH and a_w during storage appeared. According to Ball *et al.* (1955), found that cheese stored at 5^oC had average shelf life of 13.5 days with increasing of pH. ΔE is the color difference between the storage time and day 0. The results of this work showed that ΔE of juice-processed cheese was in the range of 1.28 - 2.63 and tended to increase throughout storage period. However, ΔE below 3.3 was not easily detected by untrained individual (Sakiroff *et al*., 2022). Microorganisms were not detected during 14 days storage. It can conclude that the product has a shelf life at least 14 days or 2 weeks, which must be stored in the refrigerator at 4 ^oC. According to the shelf life guideline of Second Harvest Food Bank of Middle Tennessee (2020), cheese product including soft cheese, cottage cheese, ricotta cheese and cream cheese has a shelf life about 1-2 weeks.

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