



The Study of Using Vinegar Acid as a Dangke Coagulant Alternative

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Abstract

Coagulated by papaya sap, dangke is known as a traditional dairy product belonging to the household-scale processing business in Enrekang, South Sulawesi Province, Indonesia. Vinegar is another coagulant that can be used in making dangke. This study aimed to utilize vinegar as an alternative dangke coagulant other than papaya sap, to analyze the texture of dangke, to use different salt concentrations while making dangke with vinegar, to perform proximate tests, and to conduct organoleptic tests. Dangke was made from 1 L cow's milk mixed with 5 mL of vinegar. For roughly 20 minutes, the mixture is cooked at 65–70°C while being stirred. The curd was separated from the whey and then shaped into dangke. Dangke was then soaked for 75 minutes in varied salt concentrations of 2%, 3%, and 4%. The texture analyzer (softness) result of this dangke was 125.974 g/s. It was close to the texture of traditional dangke. Proximate analyses were performed. The result that comes close to the result of traditional dangke was 3% salt-soaked dangke with a moisture content of 35.82%, an ash content of 1.44%, dissolved protein content of 0.47%, and fat content of 5.06%. An organoleptic test of preference for dangke vinegar was also carried out. The results of this study are expected to be utilized by local industries having difficulties in obtaining papaya sap as a dangke coagulant.

Keywords: dangke, coagulant, vinegar, proximate analysis, organoleptic test

1. Introduction

Indonesia has a wide variety of foods and drinks that are found throughout the country. Dangke is one of the well-known and delectable cuisines that resembles white or yellow tofu in appearance and texture but tastes like cheese. This dish will be clumped using natural ingredients or without artificial preservatives and is created with fresh milk from buffalo or cow. Nevertheless, most people know dangke as a kind of cheese (Yusuf et al., 2022). Dangke is commonly consumed by Indonesians in South Sulawesi Province (Rasbawati et al., 2014). It has been a traditional dairy product since 1905 and is made on a small scale by households in Enrekang, South Sulawesi. Dangke is made by heating fresh milk and adding papaya sap as a coagulating enzyme (Hatta et al., 2014).

The heating process is carried out at a not-too-high temperature. In the form of globular and plasma proteins, more denatured proteins will change and alter the original structure of milk proteins at higher temperatures (Malaka

et al., 2015). The dangke dough is molded into lumps and then wrapped in banana leaves using a coconut shell mold. Dangke is not only an ethnic identity for the Enrekang people but also has local wisdom and cultural values (Mustamin et al., 2022). Musra et al. (2021) have made dangke using a commercial papain enzyme and succeeded in obtaining non-bitter dangke with a shelf life depending on storage temperature. A bitter taste will appear in dangke which is made using papaya sap even at low concentrations. Because several aspects must be taken into account to prevent damage to the papaya fruit, getting papaya sap can be fairly challenging. Additionally, Pulungan et al. (2020) noted that because papaya sap has a short shelf life, it must be used as a coagulant in dangke manufacture at the peak of freshness.

Ardat et al. (2022), made dangke with different coagulant ingredients: powdered papain concentrate, fresh papaya sap, and commercial papain with three additional levels of the enzyme. To identify the type of papain and its amount of activity as a coagulant, the resulting dangke was examined physically,

chemically, and organoleptically. Based on hedonic quality tests, the preferred dangke was chewy, white, predominantly milky, and distinctive dangke taste, and not bitter. Dangke made with fresh papaya sap and freeze-dried papain coagulant produces the best dangke. However, the taste and texture of dangke made using freeze-dried papain coagulant is preferable based on the hedonic test. The addition of the enzyme dried-freeze papain provides a less bitter taste in hedonic quality compared to fresh papain at the same level of enzyme activity. In addition, using the same treatment of adding 217,14 $\mu\text{g}/\text{mg}$ coagulant, dangke made using freeze-dried papain coagulant produced 15.19 ± 1.08 mg/g proteins, higher values than that of the fresh papaya sap coagulant, which was 13.01 ± 1.2 mg/g.

Due to vinegar's ability to coagulate milk protein, we used it in this investigation as a coagulant. Vinegar is typically employed in order to coagulate the tofu. It is one of many acidic coagulants used in tofu processing other than lemon juice and glucono-d-lactone. Numerous factors, including seed variety, processing conditions, seed storage, composition stability of soybeans, and kind of coagulants, have an impact on the characteristics of soybean curd (Fasoyiro, 2014). The coagulants coagulate the vegetable protein found in soybeans. Compared to other coagulants that are now created, vinegar is very affordable and easy to obtain.

The kind of coagulants used in the production of dangke is similar to that used in the production of tofu. The shelf life of dangke is also determined by the concentration of salt used, in addition to storage temperature. Husain (2016) said that the addition of salt cannot maintain the quality of dangke during storage, but it can slow down the quality degradation. As a result, adding salt during the dangke coagulation process is not suggested since it can diminish the solubility of protein in milk and cause the protein to precipitate. In this study, salt would be added once the coagulation phase was complete.

The aims of this study is to utilize vinegar as an alternative dangke coagulant other than papaya sap. Dangke was made by heating milk and coagulation process. The quality of dangke were carried out by proximate and organoleptic tests. As a dangke coagulant alternative to papaya sap, vinegar is hoped to be effective.

2. Methodology

2.1. Materials

The research materials used in this study were fresh cow's milk (Enrekang, South Sulawesi Province, Indonesia), 25% vinegar, salt, Potassium Sodium Tartrate ($\text{C}_4\text{H}_4\text{KNaO}_6$, Merck, Germany), Sodium Carbonate (Na_2CO_3 , Merck, Germany), Sodium Hydroxide (NaOH , Merck, Germany), Copper sulfate pentahydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, Merck, Germany), n-hexane (Merck, Germany), and Folin Ciocalteu (Merck, Germany). BSA (Bovine Serum Albumin) was purchased from Sigma Aldrich.

2.2. Preliminary test

Making dangke involved combining 200 mL of fresh cow's milk with varying amounts of vinegar (0.5, 1, 2, and 3 mL). After the milk had been heated to between 65 and 70 °C, vinegar was added. Throughout the heating and coagulation phase, stirring was done every 20 minutes or so. The curd is separated from the whey by filtering and then shaped into dangke. Dangke was tested with a texture analyzer (TA XT Plus). As a contrast, dangke was also produced with coagulating papaya sap.

2.3. Dangke with vinegar coagulant

The best mixture from the preliminary test results, 200 mL of cow's milk and 1 mL of vinegar, was used to prepare up to 1 liter of cow's milk and 5 mL of vinegar. Vinegar was then added to milk after it had been heated to between 65 and 70 °C. For about 20 minutes, stirring was done intermittently while the heating and coagulation process was underway. The curd is separated from the whey by filtering and then shaped into dangke. Dangke was then soaked in a salt solution with a concentration of 2%, 3%, and 4% for 75 minutes. As a comparison, proximate analysis and organoleptic testing were carried out on dangke produced with vinegar coagulation and dangke produced with papaya sap coagulation. Proximate analysis including moisture content, ash content, protein content, and fat content was performed in order to determine the quality of dangke.

2.4. Proximate Analysis (SNI 01-2891-1992)

Moisture content analysis

A porcelain cup with a sample of 1-2 g was heated at 105 °C for three hours. The sample

was then dried after cooling in a desiccator, and its weight was calculated.

Ash content analysis

In a porcelain cup, a sample weighing 2–3 g was put, and it was burned over the burner flame. The sample was then heated to 550 °C in the furnace until flawless ashing has occurred. Sample was dried in a desiccator and weighed.

Fat content Analysis (AOAC 2005)

1-2 g sample was placed in a cotton-lined paper sleeve and heated at 80 °C for 1 hour. The sample was put into a soxhlet apparatus and extracted with hexane for roughly 6 hours. Hexane and fat from the extraction products were separated using a rotary evaporator. The separated fat from the hexane is next heated in the oven for an hour at 105°C and then weighed.

Lowry method of protein analysis

4 reagents were made (reagent A, B, C, and D). Reagent A was created by dissolving 2 grams of sodium carbonate (Na_2CO_3) and 0.4 grams of sodium hydroxide (NaOH) in 100 mL of distilled water. Reagent B was made by dissolving 0.5 g of copper sulfate pentahydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) and 1 g of Na-K-Tartrate in 100 mL of distilled water. From 50 mL of reagent A and 1 mL of reagent B, reagent C was created. Reagent D was Folin ciocalteu 1 N.

Sample preparation

The dangke sample was mashed, weighed around 1.5 g then dissolved with NaOH to pH of 10, and placed in a centrifuge for 10 minutes at 3000rpm. 0.5 mL sample was taken and placed in a test tube. 2.5 mL of reagent C was added, shaken, and left to stand for 10 minutes before 0.25 mL of reagent D was added, shaken, and left to stand for 30 minutes. The sample's absorbance was determined to be between 710 and 720 nm.

Preparation of BSA standard solutions

Standard solutions were created from 1000 ppm BSA solution. Different concentrations of standard solutions—0, 20, 30, 150, and 200 ppm—were made. The same reagent that was used to prepare the sample is added to the test tube to create the standard solution.

2.5. Organoleptic test

Dangke with vinegar coagulant (2,3, and 4% salt variations) and dangke papaya sap would be tested for texture, color, scent, and taste. Organoleptic test data was filled by panelists

distributed in online form. Organoleptic tests were carried out in the form of texture, color, scent and taste tests carried out by 27 inexperienced panelists.

2.6. Data Analysis

Moisture content

$$\text{moisture content} = \frac{w_1 - w_2}{w_1} \times 100\% \quad (1)$$

Remark:

w_1 = weight of initial sample (g)

w_2 = weight of sample after heating (g)

Ash content

$$\text{ash content} = \frac{w_1 - w_2}{w} \times 100\% \quad (2)$$

Remark:

w = weight of initial sample (g)

w_1 = weight of sample and porcelain cup, after ashing (g)

w_2 = weight of empty porcelain cup (g)

Fat content

$$\text{fat content} = \frac{w - w_1}{w_2} \times 100\% \quad (3)$$

Remark:

w = weight of sample (g)

w_1 = fat weight before extraction (g)

w_2 = fat flask weight after extraction (g)

Protein content

$$\text{protein content} = \frac{C \times \text{volume} \times \text{fd}}{\text{mg sampel}} \times 100\% \quad (4)$$

Remark:

C = concentration (ppm)

Fd = dilution factor

Organoleptic Test

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

$$S^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n} \quad s = \sqrt{S^2}$$

$$P(\bar{x} - (1,96 \times s / \sqrt{n})) \leq \mu \leq (\bar{x} + (1,96 \times s / \sqrt{n})) \quad (5)$$

Remark:

n = sum of panelist

S^2 = variance of quality values

1.96 = standard deviation coefficient at 95% level

$\bar{x}$ = average of quality value

S = standard deviation of quality value

3. Results and Discussion

3.1. Preliminary Test

Preliminary tests on the use of vinegar as coagulants were carried out by testing several comparisons between the volume of milk and the appropriate volume of vinegar coagulation to make dangke. The results are presented in Table 1. Using the results of this preliminary test and the coagulation of papaya sap in dangke as a benchmark, the proof was carried out by doing a texture test on vinegar and sour dangke using a texture analyzer.

Table 1. Result of Preliminary Test and Texture Analyzer

No.	Volume of fresh milk (mL)	Volume of vinegar (mL)	Explanation	Texture analyzer (g/s)
1.	200	0.5	No lumps	-
2.	200	1	Dense lumps and easy to form	125.974
3.	200	2	Small lumps and difficult to form	83.587
4.	200	3	Small lumps and fine granules	53.141
5.	Dangke papaya sap		Solid lump	437.835

Table 2. Proximate analysis of dangke with varying salt concentrations

No.	Dangke	Protein (%)	Fat (%)	Moisture (%)	Ash (%)
1.	Papaya sap as coagulant	0.52	5.53	41.82	2.57
2.	Vinegar coagulant and 2% salt	0.66	11.54	35.33	1.59
3.	Vinegar coagulant and 3% salt	0.47	5.06	35.82	1.44
4.	Vinegar coagulant and 4% salt	0.66	0.76	38.59	1.21

Table 1 demonstrates how the amount of vinegar had an impact on the texture of the dangke. Comparatively, the density of Dangke papaya sap is 437.835 g/s, indicating that it has a dense texture. The texture that most closely resembles the texture of dangke papaya sap was produced using a ratio of 1:200 and had a density level of 125.974 g/s, out of all the amounts of added vinegar.

leads to the formation of more curd (Horne and Lucey, 2017). In this study, 1 mL of vinegar worked best for the coagulation process.

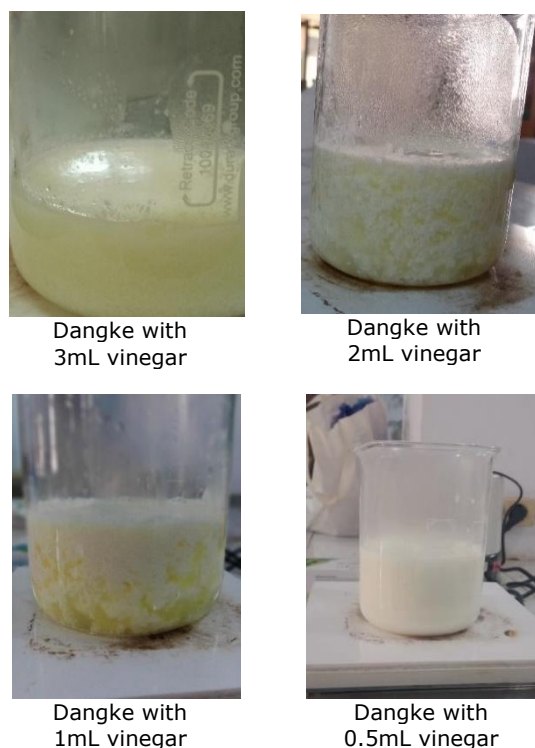
Then, 1000 mL of fresh cow's milk was combined with 5 mL of vinegar to create dangke. A 2, 3, and 4% concentration of salt moisture was used during the soaking process.

3.2. Proximate Analysis

Three samples of vinegar and one dangke of commercially available papaya sap coagulation underwent proximate analysis, which included measuring the amounts of protein, fat, moisture, and ash in each sample. Table 2 compares the outcomes of the proximate analysis.

It was possible to compare papaya sap dangke and vinegar dangke with varying salt concentrations by proximate analysis. A characteristic similar to that of dangke with papaya sap coagulation could be found in dangke vinegar that has been soaked in 3% salt. This was evident from the content's moisture, fat, protein, and ash percentages.

Dangke's moisture content increases as the salt amount does. Papaya sap dangke has the highest moisture content among all dangke using vinegar coagulant. The moisture content will affect the curd texture. The lower the moisture content, the harder the curd will be (Wardhani et al., 2018). The shelf life of dangke will be shortened due to microbial development caused by high moisture content (Nabilah et al., 2022). Rahmawati et al. (2017) applied lemon peel essential oil with an edible coating agent to extend the shelf life of tofu. Bacterial activity caused the tofu's

**Figure 1.** Result of Preliminary Test of dangke with various vinegar volume

Curd formation was strongly influenced by the level of acidity of the coagulant. At the appropriate acidity level, moisture is lost and casein molecules are incorporated, which

quality to deteriorate. Bacterial growth was facilitated by tofu's properties, including its high moisture content. It was therefore possible to draw the conclusion that dangke with vinegar coagulation had a longer product shelf life than dangke with papaya sap coagulation.

The ash content of vinegar coagulated dangke was lower than papaya sap coagulated dangke. Table 2 revealed that the ash content of dangke decreased by increasing salt concentration. The ash content of vinegar dangke ranged from 1.2% to 1.6%. It is probably due to the fact that the vinegar can dissolve the ash so dangke made with vinegar coagulation has a lower ash content.

In line with Ezeama and Dobson (2019), fresh tofu was subjected to a proximate analysis using a number of coagulants, including lime, Epson salt, and tamarind coagulant. Ash content as a result ranged from 1% to 1.8%. Dangke was found to contain minerals due to the presence of ash content. Another research (Lisanti and Arwin, 2019) concluded that the ash content of soybean seeds is 4.61–4.86%.

Fat analysis was carried out using the Soxhlet method using n-hexane as a solvent. N-hexane is the lightest solvent in removing oil and easily evaporates making it easier for reflux (Susanti et al., 2012). The fat content in dangke decreased as the salt concentration increased. The fat content in this study that was closest to the fat content in papaya sap dangke was obtained from 3% salt-soaked dangke (5.06% fat) while the lowest fat content was obtained in 4% salt-soaked dangke. The 4% salt-soaked dangke only contained 0.76% fat, far from that of papaya sap dangke which was 5.53%. All salt-soaked concentrations and the fat content produced from dangke with vinegar coagulation were still below dangke made from papaya sap. This is certainly as expected because Chalid et al. (2021) said that high fat levels could cause negative effects on health. Fat is hydrolyzed into fatty acids and glycerol during the fermentation process.

The dissolved protein levels produced from both vinegar dangke and papaya sap dangke were quite low. The low dissolved protein occurs because of the long heating time. Excessive heating can cause proteins to denature. Denaturation damages proteins and causes their levels to decrease (Mansur, 2017).

Research conducted by Al-Saedi et al. (2021) argued that protein contributed to the flavor

by producing amino acids, and also gave appearance and texture. Protein clumping occurs in the coagulation stage. Coagulation occurs with a coagulant agent in the form of vinegar. The more acid added, the higher the proteolysis, so the more dissolved protein (Wardhani et al., 2018).

Protein clumping is also affected by the salt content. High salt makes it difficult for proteins to bind water, thereby reducing protein solubility. Furthermore, protein will separate as precipitate (salting out). Protein denaturation changes its properties to be hard to dissolve.

3.3. Organoleptic Test

Organoleptic test is a test that is based on the sensing process. The organs of the body that play a role in sensing are the eyes, ears, taste buds, the sense of smell and touch. These skills include the capacity for detection, recognition, differentiation, comparison, and the expression of preferences (Sinaga et al., 2020). Dangke organoleptic test score rules are presented in Table 3.

Based on the scoring rule described on Table 3, we conducted the organoleptic or hedonic test. Negara et al. (2016), Mukhlisah et al. (2017), Setiaji et al. (2018), and Ardat et al. (2022) have analyzed their panelist scores through an organoleptic or hedonic test. Negara et al. (2016) and Ardat et al. (2022) measured texture, color, scent, and taste but Setiaji et al. (2018) measured texture, color, taste, and overall favorite. We measured the components scores as determined by Negara et al. (2016), Mukhlisah et al. (2017), and Ardat et al. (2022). Organoleptic tests were conducted in the form of texture, color, scent and taste through 27 novice panelists.

We have performed the analysis based on the test result using IBM SPSS 27.0 Application. The tests consisted of 1) Univariate analysis of variance test to figure out the significance of differences among four coagulant treatments into dangke, and 2) Duncan post hoc of multiple comparison test to figure out the homogeneous subsets from low to high scores given from the panelists.

Table 4 displays all significant differences among all kinds of dangke coagulant treatments of all categories that were the texture, color, scent, and taste of each coagulated dangke. The univariate analysis of variance test has figured out the significance of differences $p\text{-value} < 0.001$ for all categories. It proved the significant

differences of each category (texture, color, scent, and taste) among all treatments.

Table 3. Dangke organoleptic test score rule

Score	Texture	Color	Scent	Taste
5	very solid	white without yellow spots	very milky	really like
4	solid	white with slightly yellow spots	milky	like
3	rather solid	white with yellow blotches	just plain flavorless	kinda like
2	not solid	white with lots of yellow blotches	not typical of milk	just normal
1	mushy	yellow	very uncharacteristic of milk	don't like

Table 4. Dangke organoleptic test result

Kind of Dangke Coagulant Treatment	Categories			
	Texture	Color	Scent	Taste
A. Papaya sap as coagulant	4.30 ± 0.34	4.96 ± 0.08	4.52 ± 0.25	3.70 ± 0.44
B. Vinegar coagulant and 2% salt	2.59 ± 0.46	4.44 ± 0.39	2.96 ± 0.39	2.00 ± 0.40
C. Vinegar coagulant and 3% salt	3.11 ± 0.35	4.74 ± 0.21	3.67 ± 0.25	2.89 ± 0.39
D. Vinegar coagulant and 4% salt	3.44 ± 0.30	4.48 ± 0.23	3.89 ± 0.30	3.26 ± 0.50
Test result				
1) <i>Univariate analysis of variance test</i>				
The p-value	<0.001	<0.001	<0.001	<0.001
Significance at 95% confidence level	Significant difference	Significant difference	Significant difference	Significant difference
2) <i>Duncan post hoc multiple comparison test</i>				
Homogeneous subsets (low to high score)	(1) B (2) C and D (3) A	(1) B and D (2) D and C (3) C and A	(1) B (2) C and D (3) A	(1) B (2) C and D (3) D and A

The preference parameter shows that the A treatment (current known-by-people product) had the highest level of preference while the B treatment had the lowest level of liking. This result corresponded to Setiaji et al. (2018), when they found that the current product treatment (0% addition of beetroot juice) could be the best treatment based on the panelists' feelings or perceptions.

The texture test results showed that there was a significant difference among 4 coagulants with p-value < 0.001. The test successfully classified the treatment into three subsets. Treatment B resulted in a score of 2.59, meaning that the dangke textured not solid to rather solid. Treatment C and D resulted in scores 3.11 and 3.44, meaning that the dangke textured rather solid to solid. Treatment A resulted in a score 4.30, meaning that the dangke textured solid to very solid.

The color test results showed that there was a significant difference among 4 coagulants with p-value < 0.001. The test successfully classified the treatment into three subsets. However, all treatments resulted in scores 4.44 till 4.96, meaning that the dangke colored white with slightly yellow spots to white without yellow spots.

The scent test results showed that there was a significant difference among 4 coagulants with p-value < 0.001. The test successfully

classified the treatment into three subsets. Treatment B resulted in a score of 2.96, meaning that the dangke scent was not typical of milk to just plain flavorless. Treatment C and D resulted in scores 3.67 and 3.89, meaning that the dangke scent was just plain flavorless to milky. Treatment A resulted in a score 4.30, meaning that the dangke scent was milky to very milky.

The taste test results showed that there was a significant difference among 4 coagulants with p-value < 0.001. The test successfully classified the treatment into three subsets. Treatment B resulted in a score of 2.00, meaning that the dangke tasted just normal. Treatment C resulted in a score of 2.89, meaning that the dangke tasted just normal to kinda like. Treatment D and A resulted in scores 3.26 and 4.30, meaning that the dangke tasted kinda like to like.

It could be revealed from Table 4 that dangke with whatever vinegar coagulants were not yet favorable among panelists as they were local residents who used to consume the papaya sap dangke.

Comparison between dangke organoleptic test result with various coagulant treatment is presented on Table 5. Ardat et al. (2022) used fresh and dried papaya sap with different sap enzyme addition (217.14 to 651.44 $\mu\text{g}/\text{mg}$) as the treatment. Mukhlisah et al. (2017) used

different heat temperatures (70-90°C) and papain concentration (0.2-0.4%). This research used 0.5% vinegar with different salt concentration (2-4%). Various treatment resulted in not-too-far different of each best organoleptic test, ranging from 3.26 to 4.74 (from good to very good).

The findings of this study are anticipated to be put to use by regional businesses that are having trouble getting papaya sap for use as a

dangke coagulant. Because the papaya sap dangke needed more effort from makers to keep the papaya tree and fruit growing after sap extraction, the choice of producing dangke with vinegar coagulant and 3% salt or 4% salt was preferable. If it was about to promote the color, the makers might choose vinegar dangke and 3% salt-soaked but if it was about to promote the taste, the makers might choose vinegar dangke and 4% salt-soaked.

Table 5. The Comparison of The Best Organoleptic Test Result

No.	Research by	Treatment	The best organoleptic test result (Dangke treatment)			
			Texture	Color	Scent	Taste
1	Ardat et al. (2022)	Fresh and dried papaya sap with different sap enzyme addition (217.14 to 651.44 Aμ/mg).	3.63±0.98 (217.14 Aμ/mg dried papaya sap addition)	3.83±0.58 (217.14 Aμ/mg fresh papaya sap addition)	4.63±0.54 (217.14 Aμ/mg dried papaya sap addition)	4.20±1.04 (217.14 Aμ/mg dried papaya sap addition)
2	Mukhlisah et al. (2017)	Different heat temperatures (70-90°C) and papain concentration (0.2-0.4%)	3.50±0.97 (70°C temperature and 0.2% papaya sap)	4.00±0.69 (70°C temperature and 0.2% papaya sap)	3.86±1.07 (90°C temperature and 0.4% papaya sap)	4.07±0.45 (70°C temperature and 0.4% papaya sap)
3	This research	Used 0.5% vinegar with different salt concentration (2-4%)	3.44±0.30 (0.5% vinegar and 4% salt)	4.74±0.21 (0.5% vinegar and 3% salt)	3.89±0.30 (0.5% vinegar and 4% salt)	3.26±0.50 (0.5% vinegar and 4% salt)

4. Conclusion

The study's findings led researchers to the conclusion that vinegar may replace coagulants in the process of making dangke. The texture analyzer (softness) result of this dangke was 125.974 g/s. The texture of dangke with vinegar was similar to that of traditional dangke. Based on the organoleptic test result, the best dangke was coagulated by papaya sap. Vinegar and many particular concentrations of salt could be used as coagulants with many choices, although none of choice exceeded the quality and organoleptic test result of papaya sap coagulant. Vinegar coagulant and 3% salt made the best color dangke. But, vinegar and 4% salt made the best taste dangke. Other coagulants with a texture and flavor comparable to dangke papaya sap can be created as a papaya sap alternative for future research.

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