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Characteristics of *Fruit Leather* with Proportion of Carica Puree (*Carica pubescens*) : Lime Juice (*Citrus aurantifolia*) and Carrageenan and Their Shelf Life Estimation

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A B S T R A C T

Fruit leather, a delectable treat made from pureed and dehydrated fruit, can be enhanced with carica fruit (Carica pubescens), which is rich in fiber and pectin—essential components for fruit leather production. The addition of lime (Citrus aurantifolia) provides the necessary acidity for gel formation, while carrageenan is expected to improve the plasticity of the fruit leather. This study aims to evaluate carica and lime fruit leather's physicochemical and organoleptic properties and estimate its shelf life under optimal conditions.. A factorial completely randomized design (CRD) was employed with two factors: the ratio of carica puree to lime juice (95:5, 90:10, 85:15) and varying concentrations of carrageenan (0.3%, 0.6%, 0.9%), each replicated twice. Data were analyzed using analysis of variance (ANOVA) followed by Duncan's New Multiple Range Test (DNMRT) at a 5% significance level. The optimal treatment, determined to be a blend of 95% carica puree with 5% lime juice and 0.9% carrageenan, yielded the following results: moisture content of 15.33%, crude fiber content of 2.55%, pH level of 4.65, tensile strength of 4.45 N, vitamin C concentration of 12.20 mg/100g, antioxidant activity of 25.23%, color intensity of 3.24 (neutral), aroma profile of 3.04 (neutral), taste rating of 4.00 (like), texture score of 3.12 (neutral), total dietary fiber content of 4.45%, and an estimated shelf life of 70 days at 10ºC (refrigerated), 10 days at 30ºC (room temperature), and 3 days at 50ºC.These findings highlight the potential of carica and lime fruit leather as a nutritious and appealing snack, with significant shelf-life variability depending on storage conditions.

1. INTRODUCTION

1.1. Research Background

Fruit leather, a popular snack made from pureed and dehydrated fruit, offers a nutritious and convenient way to enjoy fruit's natural flavors and benefits. Producing fruit leather involves transforming fresh fruit into a concentrated form that retains essential nutrients while providing a longer shelf life. One innovative approach to enhancing the quality and appeal of fruit leather is incorporating carica fruit (Carica pubescens) and lime juice (Citrus aurantifolia) alongside carrageenan as a gelling agent.

Carica fruit (Carica pubescens) is one of the superior commodities from Wonosobo. Production in 2016, 2017, and 2018 amounted to 4,999 tons, 9,071 tons, and 11,213 tons, respectively [1]. Carica fruit cannot be consumed directly because it contains oxalate, which causes itching on the skin [2].

This fruit contains a moisture content of 77%, so it's easily damaged [3]. Carica fruit is rich in vitamin C and fiber. The crude fiber content of carica fruit is 2,58% [3] and contains pectin of 4.62-5.89% [4]. Product development at Carica is still limited, as are existing processing methods such as wet sweets, ready-to-drink drinks, jelly candies, jam, and dry sweets. According to the fiber and pectin content, Carica fruit meets the requirements to be processed into fruit leather products. This can extend the fruit's shelf life, increasing the economic value of carica fruit.

Lime (*Citrus aurantifolia*) was added as an acid in the gel formation. Lime juice has a pH of 2.72, contains vitamin C at 57,07 mg/100 g [5], and has very strong antioxidant activity with an IC_{50} value of 49,59 μg/ml [6]. Therefore, lime has the potential for developing fruit leather products.

Fruit leather is a delectable treat crafted from fruit puree that is dehydrated in an oven, resulting in a texture reminiscent of leather. A common issue encountered during the production of fruit leather is poor malleability. Fruit leather is considered good

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if it has a texture that is not too stiff or too soft [8]. The natural pectin content of the raw material is less than optimal for the gel formation process in fruit leather. Therefore, it necessitates the incorporation of gelatinous components like carrageenan. The addition of carrageenan is expected to improve the plasticity of fruit leather. Carrageenan can form a gel, thicken, control the water content in food, control texture, and stabilize it [9]. Kappa carrageenan is most often used for processing food products because it can form a stronger gel [8].

One of the qualities of fruit leather is determined by its shelf life. To ensure that the fruit leather can still be consumed and has not been damaged, shelf life information is needed [10]. According to this explanation, it is necessary to know the shelf life analysis of fruit leather.

1.2. Literature Review

Fruit leather is characterized by thin sheets measuring 2-3 mm in thickness and a moisture content ranging from 10-15%. The texture and flavor of fruit leather vary depending on the type of fruit utilized in its production [11]. The primary ingredient for fruit leather is fruit, which provides the necessary pectin and fiber to establish the texture and pliability of the final product [12].

Carica fruit is rich in nutrients, including vitamin C at 65.12 mg/100 g, vitamin A at 1771.1 µg/100 g, calcium (Ca) at 24 ppm, iron (Fe) at 1,2 ppm, and phosphorus (P) at 0.0254%. [13]. The antioxidant activity of fruit carica IC_{50} ranges from 0.983-8.843 mg/100 ml [14]. The crude fiber content of carica fruit is 2.58% [3] and contains pectin of 4.62-5.89% [4].

Lime juice (*Citrus aurantifolia*) has a pH of 2.72, vitamin C 57,07 mg/100 g [5], and very strong antioxidant activity, with an IC50 value of 49.59 µg/ml [6]. The addition of acid to raw materials containing pectin can increase gel formation [15]. The higher the acidity, the more compact the gel structure will form. However, the hydrolysis of pectin can damage the texture structure. If the acidity is lower, the gel formation will be brittle [16].

A maximum of 20% sugar addition is permissible for fruit leather [17]. Gels can be created through the process of junction zone formation involving hydrocolloids such as carrageenan in combination with sugar and acid. The addition of sugar effectively bridges the gap in the junction zone, resulting in a gel that is more robust compared to one without sugar [18].

Fruit leather is chewy and has good plasticity. When pulled, it does not break easily. The plastic texture of fruit leather is formed during the heating process in the presence of pectin, sugar, acid, and water [19]. The addition of carrageenan is expected to improve the plasticity of fruit leather. Carrageenan can form gel, thicken, control water content in food, control texture, and stabilize it [9].

1.3. Research Objective

This study seeks to establish the physicochemical and organoleptic attributes of carica and lime fruit leather, as well as to analyze their shelf life estimation.

2. MATERIALS AND METHODS

2.1. Materials and Tools

The raw material used in this research was carica fruit (*Carica pubescens*), which was cultivated in Kejajar, Wonosobo, Central Java. Lime obtained from the market in Rungkut, Surabaya, and East Java, and kappa carrageenan was obtained by *E-commerce*. The chemical used in this research is distilled water, NaOH (Merck), starch 1%, iodine 0,01 N, H_2SO_4 0,255 N, K_2SO_4 10%, ethanol 96% (Merck), methanol PA, 1,1 *diphenil*-2-*picryllhydrazil* (DPPH) (Sigma).

The tools used in making fruit leather are a blender, knife, baking dish, *cabinet dryer*, digital scale, stove, pan, and spatula. The tools for analysis include an analytical balance, beaker glass, measuring cup, erlenmeyer, funnel, measuring flask, weighing bottle, pipette, stirrer, stopwatch, pH meter, oven, desiccator, filter paper, centifuge, burette, stand and clamps, waterbath, vortex, UV-Vis spectrophotometer, and tensile strength machine.

2.2. Design of Experiment and Analysis

This study was structured using a Completely Randomized Design (CRD) with two factors. Factor I represented the ratio of carica puree to lime juice (95:5, 90:10, 85:15), while factor II denoted the carrageenan concentration (0.3%, 0.6%, 0.9%) with two replications. Treatment combinations are shown in **Table 1.**

Table 1. Treatment Combinations Fruit Leather

Proportion of carica puree : lime juice	Carrageenan		
	B1	B2	B3
A1	A1B1	A1B2	A1B3
A2	A2B1	A2B2	A2B3
A3	A3B1	A3B2	A3B3

Where,
A1B1 = carica puree : lime juice 95 : 5 and carrageenan 0.3%
A1B2 = carica puree : lime juice 95 : 5 and carrageenan 0.6%
A1B3 = carica puree : lime juice 95 : 5 and carrageenan 0.9%
A2B1 = carica puree : lime juice 90 : 10 and carrageenan 0.3%
A2B2 = carica puree : lime juice 90 : 10 and carrageenan 0.6%
A2B3 = carica puree : lime juice 90 : 10 and carrageenan 0.9%
A3B1 = carica puree : lime juice 85 : 15 and carrageenan 0.3%
A3B2 = carica puree : lime juice 85 : 15 and carrageenan 0.6%
A3B3 = carica puree : lime juice 85 : 15 and carrageenan 0.9%

The product observation data was subjected to analysis of variance (ANOVA) followed by Duncan's New Multiple Range Test (DNMRT) at a significance level of 5%. Following this, the obtained observation data was tabulated and visualized using Microsoft Excel.

2.3. Research Procedure

The carica puree production process was developed by adapting the methodology outlined in a previous study [20]. This involved a series of steps, including sorting, peeling, washing I, seed removal, cutting, washing II, and ultimately blending the fruit with water (at a ratio of 1:1 w/v) until achieving a smooth, consistent puree. The process of making lime juice was according to the method by Ref. [21] of washing, cutting into two parts, and squeezing until lime juice was obtained.

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The production of fruit leather was derived from an adaptation of prior research [22] by mixing the proportion of carica puree : lime juice according to the treatment (95:5, 90:10, 85:15) as much as 100 g, then adding carrageenan according to the treatment (0.3%. 0.6%. 0.9%). Next, 20% sugar was added, then heated on the stove at 70-80^{0}C for 2 minutes, stirring until homogeneous. Engraved on a baking dish with a thickness of 2 mm, followed by the drying procedure at 70°C for a duration of 7 hours. Subsequent to the drying phase, the fruit leather was sliced into dimensions of 5x3 cm.

2.4. Observations

2.4.1. Raw Material Observations

Examination of the raw materials carica puree and lime juice encompasses the determination of moisture content, crude fiber levels, vitamin C concentration, antioxidant activity utilizing the DPPH method, and pH values.

2.4.2. Fruit Leather Physicochemical Observations

Fruit leather is analyzed for moisture content, crude fiber, vitamin C, antioxidant activity using the DPPH method, pH, and tensile strength.

2.4.3. Fruit Leather Sensory Observations

The sensory characteristics selected to assess the excellence of fruit leather encompass color, aroma, taste, and texture. A total of 25 assessors were tasked with gauging the product's desirability utilizing a rating scale from 1 to 5, spanning from "strongly dislike" to "strongly like". The statistical analysis consisted of the application of the Friedman test.

2.4.4. Best Treatment Observations

The ideal assessment of fruit leather treatment entails the examination of dietary fiber composition and predicting its longevity. The shelf life of fruit leather is gauged through the employment of the Accelerated Shelf Life Testing (ASLT) technique utilizing an Arrhenius methodology. The fruit leather samples are subjected to three different temperature settings: 10°C (refrigeration), 30°C (room temperature), and 50°C (incubation). Evaluations were conducted on days 1, 4, 7, 10, 13, and 16. The assessment of quality deterioration encompasses factors such as moisture content, color, aroma, taste, and texture.

3. RESULT AND DISCUSSION

3.1. Physicochemical Analysis

3.1.1. Raw Material Analysis

Analysis of raw materials encompasses moisture content, crude fiber, vitamin C levels, antioxidant activity, and pH. The findings of the raw material analysis are detailed in **Table 2.**

Table 2. Raw Material Analysis

Variable	Result	
	Carica Puree	Lime juice
Moisture content (%)	88.75 ± 0.28	93.35 ± 0.48
Crude fiber (%)	1.75 ± 0.16	0.37 ± 0.29
Vitamin C (mg/100g)	31.11 ± 0.60	56.38 ± 0.31
Antioxidant activity (%)	46.85 ± 0.42	73.05 ± 0.32
pH	4.45 ± 0.07	2.45 ± 0.07

According to the findings of the raw material analysis presented in **Table 2.** The moisture content of carica puree is 88.75%, higher than the previous research by Ref. [3] with the moisture content of carica fruit is 77%. The crude fiber of carica puree is 1.75%, less than the previous research by [3] with the crude fiber of carica fruit is 2.58%. The vitamin C of carica puree is 31,11 mg/100g, less than the previous research by [13] with the vitamin C of carica fruit is 65.12%. The antioxidant activity of carica puree is 46.85%, and the pH is 4,45. Discrepancies in the analysis of raw materials stem from incorporating water in a 1:1 ratio during the production.

The lime juice exhibits a moisture content of 93,35%, surpassing the 86% reported in a previous study by [23]. The crude fiber content of lime juice is measured at 0,37%. Furthermore, the vitamin C concentration in lime juice stands at 56,38 mg/100g, showing only a slight variance from the 57,07 mg/100g value reported in a prior investigation by [5]. The antioxidant activity of lime juice is 73.05%, less than the previous research by [24] which is 81.17%. The pH of lime juice is 2,45, not much different from the previous research by [5] which is 2.72. Discrepancies in the analysis of raw materials are impacted by various factors including the maturity of the fruit, prevailing weather conditions, geographical location of cultivation, and post-harvest storage methods [25].

3.1.2. Fruit Leather Analysis

The physicochemical assessment of fruit leather encompasses measurements of moisture content, crude fiber levels, vitamin C concentration, antioxidant capacity, pH levels, and tensile strength, as detailed in **Table 3.**

3.1.2.1 Moisture Content

The moisture content in fruit leather falls within the range of 11.52-15.33%. The variance analysis reveals a noteworthy correlation between the ratio of carica puree to lime juice and the concentration of carrageenan on the moisture content of fruit leather ($p \leq 0.05$). Fig 1. The study indicates that as the proportion of carica puree increases or the proportion of lime juice decreases, along with an increase in carrageenan concentration, the moisture content of the fruit leather also increases. This relationship can be attributed to the higher levels of crude fiber found in carica puree, which measured at 1,75%, compared to lime juice at 0,37%. Fiber easily binds air because it contains free hydroxyl groups, which are polar. Carrageenan is a gel that can form a three-dimensional matrix that can bind water. This is corroborated by reference [26], as fibers contain numerous polar hydroxyl groups. As indicated by source [27], carrageenan can retain water due to the presence of free OH- ions (hydroxyl groups), which can effectively interact with H20 molecules.

Table 3. Physicochemical Analysis of *Fruit Leather*

Treatments	Physicochemical analysis					
	Moisture content (%)	Crude fiber (%)	pH	Tensile strength (N)	Vitamin C (mg/100g)	Antioxidant activity (%)
A1B1	13.84 ± 0.12	2.14 ± 0.05	4.15 ± 0.07	3.80 ± 0.28	11.52 ± 0.19	23.05 ± 0.11
A1B2	14.87 ± 0.07	2.38 ± 0.04	4.25 ± 0.21	4.10 ± 0.14	11.75 ± 0.16	24.40 ± 0.32
A1B3	15.33 ± 0.15	2.55 ± 0.03	4.65 ± 0.07	4.45 ± 0.07	12.20 ± 0.17	25.23 ± 0.21
A2B1	12.49 ± 0.05	1.79 ± 0.04	3.75 ± 0.07	2.75 ± 0.21	12.07 ± 0.28	25.75 ± 0.32
A2B2	12.92 ± 0.06	1.95 ± 0.03	3.85 ± 0.21	3.40 ± 0.14	12.83 ± 0.14	26.73 ± 0.21
A2B3	13.50 ± 0.09	2.02 ± 0.03	4.05 ± 0.07	3.75 ± 0.07	13.18 ± 0.30	28.15 ± 0.11
A3B1	11.52 ± 0.08	1.48 ± 0.05	3.40 ± 0.14	2.05 ± 0.07	13.19 ± 0.33	28.83 ± 0.21
A3B2	11.85 ± 0.17	1.54 ± 0.05	3.55 ± 0.07	2.15 ± 0.07	13.74 ± 0.15	29.43 ± 0.42
A3B3	12.11 ± 0.09	1.64 ± 0.07	3.60 ± 0.14	2.20 ± 0.14	14.97 ± 0.16	29.88 ± 0.21

3.1.2.2 Crude Fiber

The crude fiber content in fruit leather falls within the range of 14.8-2.55%. The analysis of variance indicates a noteworthy correlation between the ratio of carica puree to lime juice and the concentration of carrageenan in relation to the crude fiber content of the fruit leather (p≤0,05). Fig 2. Indicates that an increase in the ratio of carica puree, a decrease in lime juice proportion, and a rise in carrageenan concentration result in higher levels of crude fiber in the fruit leather. This is because the results of the crude fiber analysis of carica puree are higher at 1,75%, compared to lime juice at 0,37%. Carrageenan has a crude fiber content of 6,61% [28], composed of components such as cellulose, hemicellulose, polysaccharides, and lignin [29].

3.1.2.3 pH

The pH of fruit leather ranges from 1,48 to 2,55. The analysis of variance reveals that there is no substantial correlation between the proportion of carica puree to lime juice and the level of carrageenan concentration on the pH of fruit leather (p≥0,05). The greater the concentration of lime juice or the lesser the concentration of carica puree, the lower the acidity level of the fruit leather. This decline in acidity of the fruit leather resulted from the lower pH of lime juice at 2.45, as opposed to the pH of carica puree at 4.45. The greater the concentration of carrageenan, the more elevated the pH of the fruit leather. This is because kappa carrageenan has an alkaline pH level of 8.02 [30].

3.1.2.4 Tensile Strength

The tensile strength of fruit leather falls within the range of 2.05-4.45 N. The analysis of variance indicates a notable correlation between the ratio of carica puree to lime juice and the concentration of carrageenan on the tensile strength of fruit leather (p≤0,05). **Fig 3.** The study indicates that as the percentage of carica puree increases or the percentage of lime juice decreases, along with a higher concentration of carrageenan, the tensile strength of the fruit leather also increases. This outcome can be attributed to the pectin content present in carica fruit, which ranges from 4,62% to 5,89%, impacting the overall texture of the fruit leather. Pectin can form a gel with sugar and acid during the heating process. Carrageenan contains 3,6-anhydrogalactose groups, which play a role in creating the double helix structure, so it will form a strong cross-link. This is supported by [31], the tensile strength value of fruit leather is influenced by the raw material pectin. According to [32], the heating process at a higher temperature than gel formation will cause the carrageenan polymer to become random. When the temperature is lowered, the polymer forms double twists and bonds tightly. A strong gel bond will increase the tensile strength of the fruit leather.

3.1.2.5 Vitamin C

The vitamin C content of fruit leather falls within the range of 11,52-14,97 mg/100 g. The analysis of variance indicates a notable correlation between the ratio of carica puree to lime juice and the concentration of carrageenan on the vitamin C levels in fruit leather (p≤0,05). **Fig 4.** shows that the lower the proportion of carica puree or the higher the proportion of lime juice, and the higher the concentration of carrageenan, the higher the vitamin C of the fruit leather. This is because the results of the vitamin C analysis of lime juice are higher at 56,38 mg/100 g, compared to carica puree at 31,11 mg/100 g. Carrageenan contains hydroxyl groups that form a three-dimensional matrix, which can protect vitamin C compounds from damage due to heating. This is supported by [33], carrageenan can form a strong double helix structure so it can inhibit oxidation and maintain vitamin C levels.

3.1.2.6 Antioxidant Activity

The antioxidant activity level in fruit leather falls within the range of 23,05% to 29,88%. The analysis of variance indicates a meaningful relationship between the ratio of carica puree to lime juice and the concentration of carrageenan in relation to the antioxidant activity of fruit leather (p≤0,05). **Fig 5.** shows that the lower the proportion of carica puree or the higher the proportion of lime juice, and the higher the concentration of carrageenan, the higher the antioxidant activity of the fruit leather. This is because the results of the antioxidant activity analysis of lime juice are higher at 73,05%, compared to carica puree at 46,85%. Antioxidant compounds will be trapped in the cavity of the carrageenan matrix, so carrageenan can protect antioxidant compounds from damage due to heating and drying processes. This is supported by [34], carrageenan has hydroxyl groups that can form a three-dimensional matrix, which will coat the antioxidant compounds so they are not easily lost when heated.

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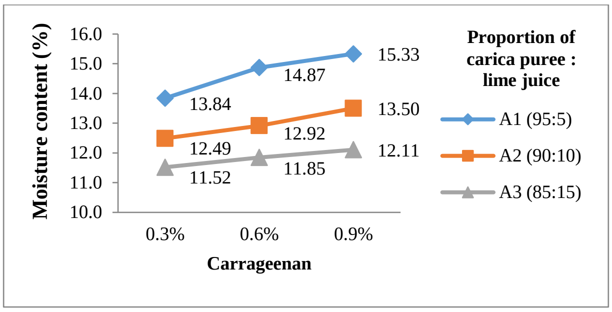

Fig 1. Relationship between proportion of carica puree : lime juice, and carrageenan on the moisture content of fruit leather

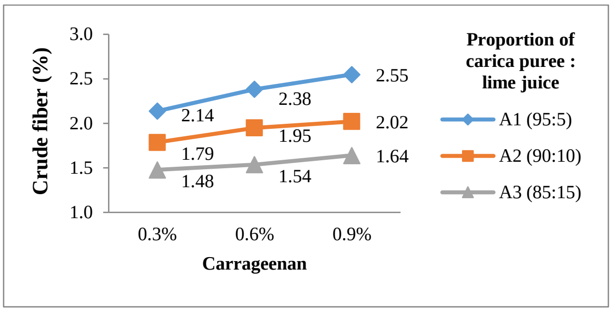

Fig 2. Relationship between proportion of carica puree : lime juice, and carrageenan on the crude fiber of fruit leather

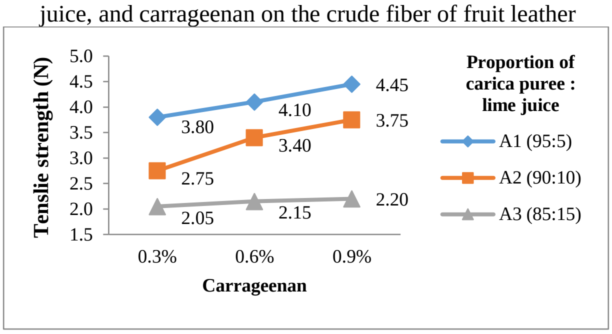

Fig 3. Relationship between proportion of carica puree : lime juice, and carrageenan on the tensile strenght of fruit leather

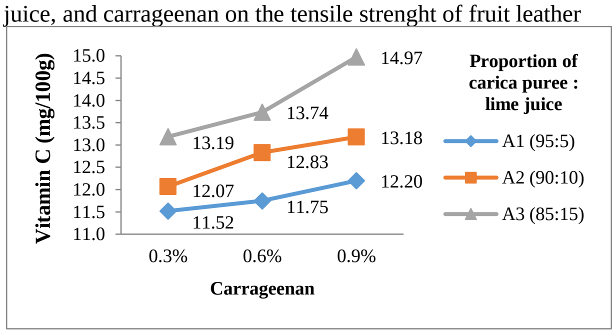

Fig 4. Relationship between proportion of carica puree : lime juice, and carrageenan on the vitamin C of fruit leather

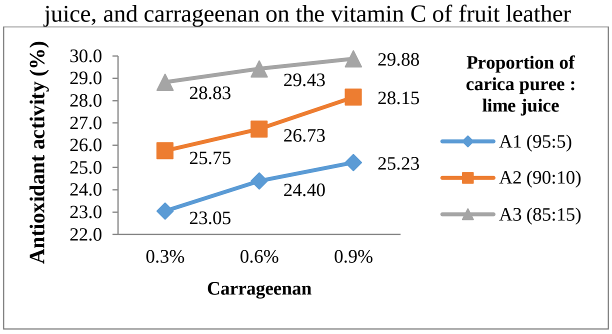

Fig 5. Relationship between proportion of carica puree : lime juice, and carrageenan on the fruit leather antioxidant activity

3.2 Sensory Analysis

The sensory evaluation of fruit leather encompasses the examination of color, aroma, taste, and texture. The illustration in **Fig 6.** depicts fruit leather made with a specific blend of carica puree, lime juice, and carrageenan concentration.

3.2.2 Color

The Friedman test results indicate a lack of significant interaction between the proportion of carica puree to lime juice and carrageenan concentration on the color hedonic score of the fruit leather. According to **Table 4, the highest color score is 3,68 (neutral). The panelists liked this result** because fruit leather has a bright yellow color. This is because carica fruit contains beta carotene pigment, which gives it a yellow color [35].

Table 4. Sensory Analysis

Treatments	Sensory attributes			
	Color	Aroma	Taste	Texture
A1B1	3.52	3.20	3.68	3.32
A1B2	3.68	3.08	3.96	2.88
A1B3	3.24	3.04	4.00	3.12
A2B1	3.44	3.48	3.60	3.20
A2B2	3.52	3.40	3.44	3.16
A2B3	3.20	3.12	3.48	3.00
A3B1	3.36	3.16	3.28	2.72
A3B2	3.20	3.24	3.44	2.60
A3B3	2.92	3.60	3.32	2.48

3.2.3 Aroma

The Friedman test results show an insignificant interaction between the proportion of carica puree: lime juice, and carrageenan concentration on the aroma hedonic score of fruit leather**.** Table 4 shows the highest aroma score is 3,60 (neutral). The panellists liked this result because fruit leather has a strong lime aroma. This is because lime contains a volatile compound called limonene, which affects the flavor [5].

3.2.4 Taste

The findings of the Friedman test reveal a noteworthy correlation between the ratio of carica puree to lime juice and the level of carrageenan concentration that influences the taste hedonic rating of fruit leather**, a**ccording to **Table 4.** The top taste rating is 4,00 (liked). The panelists found this outcome favorable due to the fruit leather's sweet, mildly tart flavor profile. The panelists expressed a preference for a reduced amount of lime juice in the recipe. The sweetness of the fruit leather can be attributed to the inclusion of 20% sugar during the preparation process.

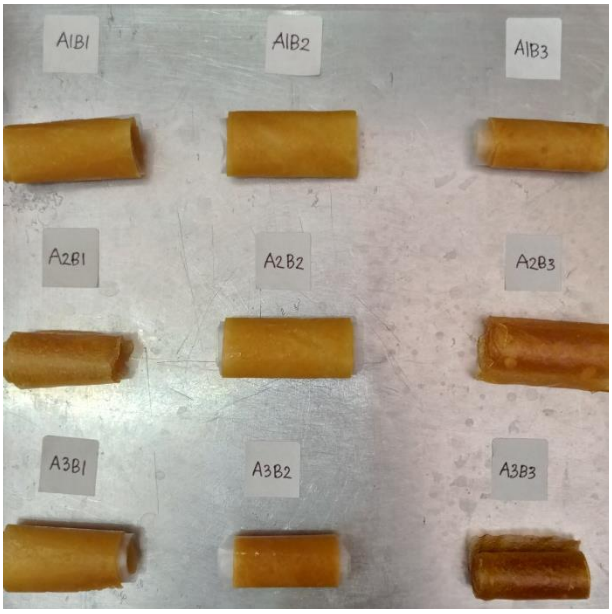

Fig 6. Picture of fruit leather with proportion of carica puree : lime juice, and carrageenan

3.2.5 Texture

The results of the Friedman test reveal a lack of significant interaction between the ratio of carica puree to lime juice and the concentration of carrageenan on the texture hedonic score of fruit leather. According to **Table 4.** The top texture score achieved was 3.32, indicating a neutral texture. This outcome was well-received by the panellists due to the chewy consistency of the fruit leather, which was not overly firm. The texture of fruit leather is directly influenced by its moisture content; a higher moisture content results in a chewier texture, while a lower moisture content yields a firmer texture. Carrageenan influences the consistency of fruit leather. Increased levels of carrageenan result in a firmer texture of fruit leather, creating a challenging chewing experience, as a result of the development of robust three-dimensional cross-links within its structure [36].

Upon evaluating efficacy values through the De Garmo method, it was determined that the optimal treatment involved a 95:5 blend of caricapuree to lime juice, along with a 9% addition of carrageenan (A1B3). The most effective treatment analysis for fruit leather incorporates the assessment of dietary fiber content (%) and the estimation of shelf life utilizing the ASLT method with an Arrhenius approach.

3.3 Best Treatment Analysis

3.3.2 Dietary Fiber

The total dietary fiber analysis includes soluble and insoluble fiber. The results are shown in **Table 5.**

Table 5. Dietary Fiber Analysis

Variable	Result (%)
Soluble dietary fiber	0.14
Insoluble dietary fiber	4.31
Total dietary fiber	4.45

According to the result of the dietary fiber analysis shown in **Table 5.** total dietary fiber is 4.45% includes soluble dietary fiber is 0.14% and insoluble dietary fiber is 4.31%. The dietary fiber of carica fruit and carrageenan influences the dietary fiber of fruit leather. According to previous research [3], carica fruit contains 2,80% total dietary fiber and 0,14% soluble dietary fiber. According to [37], kappa carrageenan has a total dietary fiber of 69.3 g including insoluble dietary fiber of 58.6 g and soluble dietary fiber of 10,7 g on a dry basis.

3.3.3 Shelf Life Estimation

The shelf life estimation analysis for the rate of quality decrease includes moisture content (%), color, aroma, taste, and texture.

3.3.3.1 Moisture Content

According to **Table 6.** the moisture content of carica and lime fruit leather decreased during storage. The moisture content stored at 10^{0}C ranges from 13.02-15.10%, at 30^{0}C ranges from 12.24-14.91%, and 50^{0}C ranges from 9.79-14.73%. The relationship between decreasing moisture content, temperature, and storage time was obtained by a linear regression equation as shown in **Table 7.**

Table 6. Moisture content of fruit leather during storage

Storage time (day)	Moisture content (%)		
	Temperature 10^{0}C	Temperature 30^{0}C	Temperature 50^{0}C
1	15.10	14.91	14.73
4	14.95	14.68	13.57
7	14.62	14.09	12.84
10	14.10	13.12	11.47
13	13.58	12.76	10.36
16	13.02	12.24	9.79

Table 7. Linear regression equation for moisture content

T (^{0}C)	Linear regression equation	
	Order 0	Order 1
10	y = -0.4292x + 15.7320 R^2 = 0.9695	y = -0.0304x + 2.7604 R^2 = 0.9639
30	y = -0.5735x + 15.6420 R^2 = 0.9760	y = -0.0422x + 2.7577 R^2 = 0.9756
50	y = -1.0192x + 15.6910 R^2 = 0.9904	y = -0.0847x + 2.7810 **R^2 = 0.9907**

The decrease in moisture content follows first-order reaction kinetics According to the largest R^2 value of 0,9907. Then, determine the Arrhenius equation by graphing the relationship between 1/T and Ln k as shown in **Table 16.**

3.3.3.2 Color

Table 8. Color hedonic score of fruit leather during storage

Storage time (day)	Color hedonic score		
	Temperature 10^{0}C	Temperature 30^{0}C	Temperature 50^{0}C
1	3.55	3.60	3.30
4	3.35	3.30	2.00
7	3.20	3.35	1.90
10	3.35	3.20	1.80
13	3.30	3.10	1.75
16	3.15	3.00	1.55

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According to **Table 8.** color hedonic score of carica and lime fruit leather decreased during storage. The color hedonic score stored at 10^0C ranges from 3.15-3.55, at 30^0C ranges from 3.00-3.60, and at 50^0C ranges from 1.55-3.30. A linear regression equation obtained the relationship between temperature and storage time and decreasing color hedonic score, as shown in **Table 9.**

Table 9. Linear regression equation for color hedonic score

T (^{0}C)	Linear regression equation	
	Order 0	Order 1
10	y = -0.0571x + 3.5167 R² = 0.5811	y = -0.0171x + 1.2579 R² = 0.5796
30	y = -0.1071x + 3.6333 R² = 0.9046	y = -0.0327x + 1.2940 **R² = 0.9141**
50	y = -0.2743x + 3.0100 R² = 0.6616	y = -0.1209x + 1.1091 R² = 0.7377

The decrease in color hedonic score follows first-order reaction kinetics According to the largest R^2 value of 0,9141. Then, determine the Arrhenius equation by graphing the relationship between 1/T and Ln k as shown in **Table 16.**

3.3.3.3 Aroma

Table 10. Aroma hedonic score of fruit leather during storage

Storage time (day)	Aroma hedonic score		
	Temperature 10^0C	Temperature 30^0C	Temperature 50^0C
1	3.45	3.35	3.35
4	3.35	3.20	3.00
7	3.30	3.15	2.75
10	3.25	3.20	2.40
13	3.40	3.00	2.35
16	3.15	2.85	2.20

According to **Table 10.** aroma hedonic score of Carica and lime fruit leather decreased during storage. The aroma hedonic score stored at 10^0C ranges from 3.15-3.45, at 30^0C ranges from 2.85-3.35, and at 50^0C ranges from 2.20-3.35. The relationship decreasing aroma hedonic score, between temperature and storage time was obtained by a linear regression equation as shown in **Table 11.**

Table 11. Linear regression equation for aroma hedonic score

T (^{0}C)	Linear regression equation	
	Order 0	Order 1
10	y = -0.0400x + 3.4567 R² = 0.4800	y = -0.0122x + 1.2411 R² = 0.4826
30	y = -0.0871x + 3.4300 R² = 0.86430	y = -0.0282x + 1.2367 R² = 0.8594
50	y = -0.2300x + 3.4800 R² = 0.9507	y = -0.0849x + 1.2700 **R² = 0.9659**

The decrease in aroma hedonic score follows first-order reaction kinetics, according to the largest R2 value of 0.9659. Then, determine the Arrhenius equation by graphing the relationship between 1/T and Ln k, as shown in **Table 16.**

3.3.3.4 Taste

Table 12. Taste hedonic score of fruit leather during storage

Storage time (day)	Taste hedonic score		
	Temperature 10^0C	Temperature 30^0C	Temperature 50^0C
1	4.05	4.00	4.00
4	4.05	4.00	3.95
7	4.00	3.95	3.65
10	4.05	3.90	3.35
13	3.95	3.70	3.15
16	3.80	3.65	3.10

According to **Table 12.** taste hedonic score of Carica and lime fruit leather decreased during storage. The taste hedonic score stored at 10^0C ranges from 3,80-4,05, at 30^0C ranges from 3,65-4,00, and at 50^0C ranges from 3,10-4,00. The relationship decreasing taste hedonic score, between temperature and storage time was obtained by a linear regression equation as shown in **Table 13.**

Table 13. Linear regression equation for taste hedonic score

T (^{0}C)	Linear regression equation	
	Order 0	Order 1
10	y = -0.0429x + 4.1333 R² = 0.6650	y = -0.0109x + 1.4200 R² = 0.6622
30	y = -0.0771x + 4.1367 R² = 0.8801	y = -0.0201x + 1.4222 R² = 0.8762
50	y = -0.2057x + 4.2533 R² = 0.9576	y = -0.0583x + 1.4610 **R² = 0.9603**

The decrease in taste hedonic score follows first-order reaction kinetics, according to the largest R2 value of 0.9603. Then, determine the Arrhenius equation by graphing the relationship between 1/T and Ln k, as shown in **Table 16.**

3.3.3.5 Texture

Table 14. Texture hedonic score of fruit leather during storage

Storage time (day)	Texture hedonic score		
	Temperature 10^0C	Temperature 30^0C	Temperature 50^0C
1	3.35	3.25	3.25
4	3.25	3.10	2.90
7	3.20	3.15	2.70
10	3.15	3.05	2.35
13	3.10	2.85	2.25
16	3.05	2.60	1.95

According to **Table 14.** texture hedonic score of carica and lime fruit leather decreased during storage. The texture hedonic score stored at 10^0C ranges from 3.05-3.35, at 30^0C ranges from 2.60-3.25, and at 50^0C ranges from 1,95-3,25. The relationship decreasing texture hedonic score, between temperature and storage time was obtained by a linear regression equation as shown in **Table 15.**

Table 15. Linear regression equation for texture hedonic score

T (^{0}C)	Linear regression equation	
	Order 0	Order 1
10	y = -0.0571x + 3.3833 R^2 = 0.9796	y = -0.0179x + 1.2201 R^2 = 0.9832
30	y = -0.1171x + 3.4100 R^2 = 0.8577	y = -0.0400x + 1.2359 R^2 = 0.8436
50	y = -0.2514x + 3.4467 R^2 = 0.9848	y = -0.0987x + 1.2737 **R^2 = 0.9877**

The decrease in texture hedonic score follows first-order reaction kinetics, according to the largest R2 value of 0,9877. Then, determine the Arrhenius equation by graphing the relationship between 1/T and Ln k, as shown in **Table 16.**

Table 16. Arrhenius equation, R^2 value, Ea, and k

Parameters	Arrhenius Equation	R^2	Ea (cal/molK)	k
Moisture content	Ln k = -2319.7 (1/T) + 4.6357	0.9421	4606.9242	0.028407 0.048798 0.078392
Color	Ln k = -4430.1 (1/T) + 11.463	0.9479	8798.1786	0.015130 0.042520 0.105138
Aroma	Ln k = -4413.7 (1/T) + 11.129	0.9865	8765.6082	0.011480 0.032140 0.079206
Taste	Ln k = -3803.7 (1/T) + 8.8339	0.9633	7554.1482	0.009984 0.024245 0.052746
Texture	Ln k = -3890.9 (1/T) + 9.6929	**0.9949**	7727.3274	0.017321 0.042923 0.095062

According to reference [38], the primary factor in selecting quality parameters to establish the shelf life of products is the parameter that exhibits the most rapid decline during storage, as indicated by the highest correlation coefficient (R^2) value. According to **Table 16.** the largest correlation coefficient (R^2) value for the texture parameter. Hence, the primary factor influencing the longevity of carica and lime fruit leather was the texture criterion. The findings regarding the shelf life of the fruit leather can be observed in **Table 17.**

Table 17. The shelf life results of carica and lime fruit leather

Temperature		k value	Shelf life
^{0}C	K		
10	283	0,017321	70 days
30	303	0,042923	10 days
50	323	0,095062	3 days

According to **Table 17.** The projected longevity of carica and lime fruit leather is 70 days at 10ºC, 10 days at 30ºC, and 3 days at 50ºC.

4 CONCLUSION

This study demonstrates a significant correlation between the ratio of carica puree to lime juice and the concentration of carrageenan in fruit leather, influencing key attributes such as moisture content, crude fiber, tensile strength, vitamin C, antioxidant activity, taste, and texture. However, no significant correlation was observed for pH, color, and aroma. The optimal formulation was determined to be a ratio of 95:5 carica puree to lime juice, with 0.9% carrageenan. This combination yielded the following results: a moisture content of 15.33%, crude fiber content of 2.55%, pH level of 4.65, tensile strength of 4.45 N, vitamin C concentration of 12.20 mg/100g, the antioxidant activity of 25.23%, a color rating of 3.24 (neutral), an aroma rating of 3.04 (neutral), a taste rating of 4.00 (liked), a texture rating of 3.12 (neutral), and a total dietary fiber content of 4.45%. Shelf life estimation revealed that this fruit leather formulation can be stored for 70 days at 10ºC (refrigerated), 10 days at 30ºC (room temperature), and 3 days at 50ºC. These findings indicate that the selected formulation not only enhances the sensory and nutritional properties of fruit leather but also provides a reasonable shelf life under various storage conditions, making it a viable option for both consumers and manufacturers.

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REFERENCE

[1] Sugiyarto, A., dan Fajri, I. 2021. Pembuatan Carica *Fruit Leather* Dengan Suhu Pengeringan Yang Berbeda. Jurnal Pariwisata Lokal. Vol 2(1): 1-17.

[2] Wulan, S.S., M. Sui., dan E. Sumayati. 2019. Pengaruh Konsentrasi Garam dan Lama Perendaman Terhadap Mutu Manisan Carica (*Carica pubescens*). Jurnal Ilmu-ilmu Pertanian Agrika. Vol 13(1): 23-32.

[3] Widarni, S., S.D. Astuti., dan Furqon. 2018. Produk “*Ready to Drink*” Buah Carica di Wonosobo Jawa Tengah. Prosiding Seminar Nasional Universitas Jenderal Soedirman. 373-388.

[4] Pratiwi, E., Fitriana, I., dan Larasati, D. 2016. Ekstraksi Pektin Dari Limbah Kulit Buah Carica Dieng (*Carica pubescens*). Prosiding Seminar Nasional Pengembangan Teknologi Pertanian.Vol 4(5): 160-167.

[5] Assalam, S., Gozali, T., Ikrawan, Y., dan Nurfalia, I. 2023. Optimalisasi Formula Minuman Olahan Jeruk

 https://doi.org/10.29165/ajarcde.v8i2.394

Nipis (Citrus aurantifolia) Dengan Parameter Karakteristik Produk. Jurnal Penelitian Pertanian Terapan, Vol 23(2): 288-301.

[6] Permata, A.N., A. Kurniawati., dan B. Lukiati. 2018. *Screening* Fitokimia, Aktivitas Antioksidan dan Antimikroba Pada Buah Jeruk Lemon (*Citrus limon*) dan Jeruk Nipis (*Citrus aurantifolia*). Jurnal Ilmiah Ibnu Sina. Vol 3(1): 64-76.

[7] Naz, R. 2012. *Physical Properties*, *Sensory Attributes and Consumer Preference of Fruit Leather.* Pakistan Journal of Food Sciences. Vol 22(4): 188-190.

[8] Historiasih, R.Z. 2010. Pembuatan *Fruit Leather* Sirsak-Rosella. Skripsi. Universitas Pembangunan Nasional "Veteran" Jawa Timur. Surabaya.

[9] Subaryono dan Utomo, B.S. 2006. Penggunaan Campuran Karagenan dan Konjak dalam Pembuatan Permen Jelly. Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan. Vol 1(1): 19-26.

[10] Arif, A.B. 2016. Metode *Accelerated Shelf Life Testing* (ASLT) Dengan Pendekatan Arrhenius Dalam Pendugaan Umur Simpan Sari Buah Nanas, Pepaya, dan Cempedak. Informatika Pertanian. Vol 25(2): 189-198.

[11] Astuti, T., Widowati, E., dan Atmaka, W. 2015. Kajian Karakteristik Sensoris, Fisik dan Kimia *Fruit Leather* Pisang Tanduk (*Musa comoculata* L.) Dengan Penambahan Berbagai Konsentrasi Gum Arab. Jurnal Teknologi Hasil Pertanian. Vol 8(1): 6-14.

[12] Nurainy, F., dan Koesoemawardhani, G. 2006. Efek Penambahan Rumput Laut Terhadap Karakteristik *Fruit Leather* Sirsak. Penelitian. Fakultas Pertanian Universitas Lampung. Bandar Lampung.

[13] Rahayu, E.S. dan Pribadi, P. 2012. Kadar Vitamin dan Mineral Dalam Buah Segar dan Manisan Basah Karika Dieng (*Carica pubescens Lenne* & K. *Koch*). Biosaintifika. Vol 4(2): 89-97.

[14] Laily, A.N., Suranto., dan Sugiyarto. 2012. Characteristics of Carica pubescens of Dieng Plateau, Central Java According to Its Morphology, Antioxidant, and Protein Pattern. Nusantara Bioscience. Vol 4(1): 16-21.

[15] Desrosier, N.W. 2008. Teknologi Pengawetan Pangan. Universitas Indonesia Press. Jakarta.

[16] Gaffar, R., Lahming., dan M. Rais. 2018. Pengaruh Konsentrasi Gula Terhadap Mutu Selai Kulit Jeruk Bali (*Citrus maxima*). Jurnal Pendidikan Teknologi Pertanian. Vol 3: 117-125.

[17] Delong, D. 2006. *How to Dry Food*. Penguin Group. USA. 25-28.

[18] Faradian, F. 2001. Pengujian Kualitas Minuman Ringan Berkarbonat Terhadap Pengaruh Penyimpanan. Skripsi. Fakultas Teknologi Pertanian Institut Pertanian Bogor. Bogor.

[19] Lawalata, V.N., Ega, L., Sipahelut, S.G., dan Tetelepta, G. 2015. Mutu Organoleptik *Fruit Leather* Gandarian (*Bouea macrophylla*). Jurnal Agroforestri. Vol 10(2): 127-130.

[20] Mukminah, N., Azzahra, H., dan Fathurohman, F. 2022. Pengaruh Konsentrasi Gula Terhadap Karakteristik Kimia dan Organoleptik Selai Carica (*Carica pubescens* L.). Jurnal Edufortech. Vol 7(2): 131-139.

[21] Haq, G.I., A. Permanasari., dan H. Sholihin. 2010. Efektivitas Penggunaan Sari Buah Jeruk Nipis Terhadap Ketahanan Nasi. Jurnal Sains dan Teknologi Kimia. Vol 1(1): 44-58.

[22] Aryani, I., Malle, S., dan Reta. 2022. Inovasi Pembuatan Fruit Leather Buah Jeruk Pamelo (Citrus maxima) dengan Penambahan Kulit Buah Naga. Agrokompleks. Vol 22(1): 24-33.

[23] Sarwono, B. 2001. Khasiat dan Manfaat Jeruk Nipis. AgroMedia. Jakarta.

[24] Sudjatini. 2016. Sifat Pro-Oksidan Sari Jeruk Nipis (Citrus aurentifolia) Terhadap Aktifitas Antioksidan Teh Hijau (Camellia sinensis). Jurnal Agrotech. Vol 1(1): 19-26.

[25] Khurniyati, M.I. 2015. Pengaruh Konsentrasi Natrium Benzoat dan Kondisi Pasteurisasi (Suhu dan Waktu) terhadap Karakteristik Minuman Sari Apel Berbagai Varietas: Kajian Pustaka. Jurnal Pangan dan Agroindustri. Vol 3(2): 523-529.

[26] Prasetyo, A dan Winarti, S. 2019. Karakteristik Effervescent Prebiotik Galaktomanan dari Ampas Kelapa. Jurnal Teknologi Pangan. Vol 13(2): 68-76.

[27] Harijono, T. Estiasih., W.B. Sunarharum., dan Rakhmita, I.S. 2010. Karakteristik Kimia Ekstrak Polisakarida Larut Air Dari Umbi Gembili (Dioscorea esculenta) yang Ditunaskan. Jurnal Teknologi Pertanian. Vol 11(3): 162-169.

[28] Yasita, D. dan Rachmawati, I. D. 2009. Optimasi Proses Ekstraksi Pada Pembuatan Karaginan dari Rumput Laut Eucheuma Cottoni untuk Mencapai Foodgrade. Jurusan Teknik Kimia Fakultas Teknik Universitas Diponegoro Program Studi Kimia, Fakultas MIPA, Universitas Tanjungpura.

[29] Safitri, E., Sudarno., dan Kusdarwati, R. 2017. Pengaruh Penambahan Karagenan Terhadap Kandungan Serat Kasar dan Peningkatan Nilai Gel Strenght Pada Produk Kamaboko dari Komposit Ikan Belanak dan Ikan Mujare. Journal of Marine and Coastal Science. Vol 6(2): 101-114.

[30] Siregar, A.H. 2016. Pembuatan Zat Warna Alam Dari Tumbuhan Berasal Dari Daun. Jurnal Teknik Industri Universitas Pembangunan Nasional. 12: 103-110.

[31] Winarti, S., Sarofa, U., dan Wulandari, V.V. 2020. Karakteristik Fruit Leather Dari Buah Bidara (Ziziphus Mauritiana) dan Kulit Buah Naga Merah Serta Rumput Laut Sebagai Bahan Pengikat. Agrointek. Vol 14(1): 99-111.

[32] Luketsi, W.P., Wibowo, R.K.P., dan Ramadiansyah, B.A.G. 2021. Pengaruh Pengeringan Terhadap Kuat Tarik dan Elastisitas Fruit Leather dari Buah Nanas (Ananas cosmosus L.) Subgrade. Prosiding SNST Fakultas Teknik Universitas Wahid Hasyim Semarang. 11-16.

[33] Agustin, F., Dwi, W., dan Putri, R. 2014. Pembuatan Jelly Drink *Averrhoa blimbi* L. (Kajian Proporsi Belimbing Wuluh : Air dan Konsentrasi Karagenan). Jurnal Pangan dan Agroindustri. Vol 2(3): 1-9.

[34] Masuda, Y., H. Kikuzaki., M. Hisamoto., and N. Nakatani. 2004. *Antioxidant Properties of Ginger Related Compounds from Ginger*. Biofactors.

[35] Astawan, M., dan Andreas, L.K. 2008. Khasiat Warna-warni Makanan. Gramedia Pustaka Utama. Jakarta.

[36] Fitantri, A., Parmanto, N., dan Praseptiangga, D. 2014. Kajian Karakteristik Fisikokimia dan Sensoris Fruit Leather Nangka (Artocarpus heterophyllus) dengan Penambahan Karaginan. Jurnal Teknologi Sains Pangan. Vol 3(1): 26-34.

[37] Sidi, C., E. Widowati., dan A. Nuraiwi. 2014. Pengaruh Penambahan Karagenan Pada Karakteristik Fisikokimia dan Sensoris Fruit Leather Nanas (Ananas comosus L.Merr.) dan Wortel (Daucus carota). Jurnal Aplikasi Teknologi Pangan. 4: 122-127.

[38] Rahmanto, S.A., Parnanto, N.H.R., dan Nursiwi, A. 2014. Pendugaan Umur Simpan Fruit Leather Nangka (Arrtocarpus heterophyllus) Dengan Penambahan Gum Arab Menggunakan Metode ASLT Modl Arrhenius. Jurnal Teknosains Pangan. Vol 3(3): 35-43.