



Dr. Rahmawati, ST, M.Si. <rahmafarasara@usahid.ac.id>

[Jurnal Teknologi] Editor Decision (RR) "The CHARACTERISTIC OF DEWA STARFRUIT-RED GUAVA FRUIT LEATHER DUE TO THE ADDITION OF GUM ARABIC"

Professor Dr. Rosli Md Illias <journal_utm@utm.my>

Thu, Sep 9, 2021 at 10:17 AM

To: Rahmawati Farasara <rahmafarasara@usahid.ac.id>, Kharimatul Fachriah <khafachrima@gmail.com>

Dear Rahmawati Farasara, Kharimatul Fachriah:

We have reached a decision regarding your submission to Jurnal Teknologi, "The CHARACTERISTIC OF DEWA STARFRUIT-RED GUAVA FRUIT LEATHER DUE TO THE ADDITION OF GUM ARABIC".

Our decision is: REVISION REQUIRED

2. Reviewers have now commented on your paper. You will see that they are advising you to revise your manuscript. If you are prepared to undertake the work required, I would be pleased to consider your article for publication.

3. For your guidance, reviewers' comments are attached.

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- c) Filled document "JT Invoice Request and Payment Instructions **REGULAR ISSUE**" to enable us to prepare a formal invoice for payment purposes.

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Yours sincerely;

Professor Dr. Rosli Md Illias
Chief Editor, Jurnal Teknologi
Universiti Teknologi Malaysia, Malaysia
r-rosli@utm.my

Reviewer A:
Recommendation: See Comments

Referee's comments

A very good manuscript presented very well technically, with a sufficient amount of information, supported by statistically sound data— pleasant to read.

A. Evaluations Please evaluate the paper according to the following criteria. Check the item if you agree to the statement:

- The topic is important and relevant for publication
- The work presented in the manuscript is original
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- The manuscript uses appropriate language and styles
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- The order of the presentation is satisfactory
- The abstract adequately summarizes the content of the manuscript
- The introduction is adequately developed
- The problem described in the manuscript is clearly stated
- The adopted methodology described in the manuscript is sound
- The findings of this manuscript are correctly interpreted
- The manuscript is free from obvious errors
- The quality of figures and illustrations is acceptable for publications
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B. Suggestions to the author(s) What can the author(s) do to improve the quality of this paper?

Some sentences are too long. Suggest simplifying them wherever necessary to improve delivery.

Please refer to the attachment: [Jurnal Teknologi _ Review_16642-Article Text-52037-1-4-20210309.doc](#)

Reviewer B:

Recommendation: Resubmit for Review

Referee's comments

The experiment is actually simple, but it rich information. It is also unique related to the use of tropical fruits with specific cultivar / variety. It will much sound when the article is discussed in a focus way, rich with related references, and presented in a dynamic discussion, not monotone

A. Evaluations Please evaluate the paper according to the following criteria. Check the item if you agree to the statement:

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Reviewer C:

Recommendation: Revisions Required

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- The introduction is adequately developed
- The problem described in the manuscript is clearly stated
- The adopted methodology described in the manuscript is sound
- The findings of this manuscript are correctly interpreted
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- The quality of figures and illustrations is acceptable for publications
- The manuscript does not dwell on any sensitive issues

B. Suggestions to the author(s)What can the author(s) do to improve the quality of this paper?

Interesting research, because it utilizes local commodities to produce functional food. However, the characteristics of the product that will be answered in this article must be mentioned in the title of the article.

The discussion is quite good, but need to be compared with other studies using gum arabic or other hydrocolloids.

In addition, it is necessary to pay attention to the reference numbering.

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[Jurnal Teknologi] Editor Decision (RR) "The CHARACTERISTIC OF DEWA STARFRUIT-RED GUAVA FRUIT LEATHER DUE TO THE ADDITION OF GUM ARABIC"

Dr. Rahmawati, ST, M.Si. <rahmafarasara@usahid.ac.id>
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Sat, Sep 11, 2021 at 5:38 AM

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[Jurnal Teknologi] Editor Decision (RR) "The CHARACTERISTIC OF DEWA STARFRUIT-RED GUAVA FRUIT LEATHER DUE TO THE ADDITION OF GUM ARABIC"

Dr. Rahmawati, ST, M.Si. <rahmafarasara@usahid.ac.id>
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Wed, Sep 29, 2021 at 8:53 PM

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Dr. Rahmawati, ST, M.Si. <rahmafarasara@usahid.ac.id>
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Dr. Rahmawati, ST, M.Si. <rahmafarasara@usahid.ac.id>
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Sun, Nov 28, 2021 at 8:06 AM

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Thank you

Professor Dr. Rosli Md Illias
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Tue, Nov 30, 2021 at 9:27 PM

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Notification of Publication Jurnal Teknologi (Sciences & Eng.) Regular Issue: Vol. 84 No. 1: January 2022

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Mon, Dec 20, 2021 at 2:18 PM

To: Fauziyah Salehuddin <fauziyah@utem.edu.my>, "Rahmawati, ST, M.Si. Dr." <rahmafarasara@usahid.ac.id>, Uyi Sulaeman <sulaeman@unsoed.ac.id>, "Dr. Gito Sugiyanto, ST., MT." <gito.sugiyanto@unsoed.ac.id>, Hartati Ahmad <hartati@unm.ac.id>, Dr Teo Chee Loong <anthony1109@hotmail.my>, "Prof. Madya Dr. Geoffery James Gerusu" <geoffery@upm.edu.my>, jurifa@utem.edu.myshukur, ALIREZA FIROUZI <falireza3@graduate.utm.my>, Shukur <shukur@utem.edu.my>, Erna Yuliyaty <deeyuliyati@gmail.com>, Nensok Mohammed Hassan <nensok@student.usm.my>, SALMANIAN MOHAMMADHASSAN / UPM <gs57464@student.upm.edu.my>, Sismanto Sismanto <sismanto@ugm.ac.id>, Muzamir Hasan <muzamir@ump.edu.my>, "Asst. Prof. Mostafa Moghadasi" <m.moghadasi@basu.ac.ir>, Omid Shabazi Ghozani <omidsh_68@yahoo.com>, Soheil Taeepoor <soheiltaeepoor@ymail.com>, "DR. MOHD YAZED AHMAD" <myaz@um.edu.my>, "Dr Mohammad Nazri Mohd Jaafar C23-2XX(JAA)" <nazri@mail.fkm.utm.my>, Evi Susanti <evi.susanti.fmipa@um.ac.id>, Dr Jahariah Sampe <jahariah@ukm.edu.my>, NITIN AGARWAL <agarwal_nitin88@rediffmail.com>, Mohamad Khairi Ishak <khairiishak@usm.my>, "FADZILAH @ ADIBAH BINTI ABD. MAJID" <f.adibah@umt.edu.my>

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Vol. 84 No. 1 January 2022

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**CHARACTERISTIC OF DEWA STARFRUIT-
RED GUAVA FRUIT LEATHER DUE TO THE
ADDITION OF GUM ARABIC**

Authors 2021

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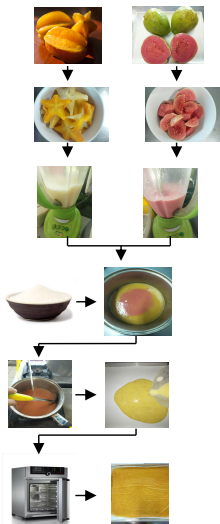
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Graphical abstract



Abstract

Fruit leather is one of the processed fruit products. It's shape similar to a thin sheet that can be rolled, has an elastic texture, and has specific flavour. One of the suitable fruit that can be processed to fruit leather is starfruit and guava. The aim of this research was to study the characteristics of the fruit leather made from starfruit (Dewa variety) and red guava which were added with Arabic gum with different concentration (0%, 0.5%, 1%, 2%, and 2.5%). Data were analyzed by analysis of variance (ANOVA) at $\alpha = 0.05$. The result showed that the addition of Arabic gum had a significant effect on tensile strength, water, ash, vitamin C content, and pH value, but it did not has a significant effect on crude fiber, water activity content, total bacteria, and total yeast and mold. While the addition of Arabic gum had a significant effect on color and texture sensory test. The best fruit leather was determined based on the physicochemical and sensory test, and it showed that the addition of 0.5% Arabic gum was the best. Characteristics of the best starfruit and guava fruit leather were tensile strength value 437.38 gf, water content 7.38%, ash content 2.02%, vitamin C content 77.08%, crude fiber content 1.85%, pH value 4.22, water activity value 0.48, total bacteria < 2.5 CFU/g, total yeast and mold < 1 CFU/g with golden yellow color, slightly strong starfruit aroma, strong starfruit flavor, and elastic fruit leather texture.

Keywords: Arabic gum, Dewa starfruit, fruit leather, physicochemical properties, red guava, sensory properties

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Commented [A3]: fruit leather, starfruit, guava, Arabic gum, physicochemical properties, sensory properties

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1.0 INTRODUCTION

Fruit leather is a fruit preserved product that is growing rapidly in various countries in the world [1] which can be consumed as candy or snacks [2]. Fruit leather is made from drying fruit puree to form a thin sheet that can be rolled with a thickness of 2 - 3 mm, contains 10-20% water, has a plastic texture, and has a specific consistency and flavor according to the type of fruits used [1].

In Indonesia, fruit leather is not widely known, but several studies have been conducted on processed fruit leather from various kinds of fruit, such as apple fruit leather [2], red guava fruit leather [3], papaya fruit leather [4], and others. Currently in Indonesia, fruit leather is not yet popular, therefore, the Dewa starfruit fruit leather will be made, due to it is one of the best starfruit variety in Indonesia and the world, which has become an icon of Depok city and is a local resource for the city of Depok [5]. In addition, the

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making of Dewa starfruit fruit leather is expected to be an alternative for souvenirs of Depok City. In order to improve the quality of the produced fruit leather, it is formulated with red guava, which is also grows a lot in the city of Depok. Red guava is rich in vitamin C (64.69 mg / 100 g of material), has a higher pectin content than starfruit (4.1%) [7] [8]. In red guava, carotenoids are also found which have antioxidant activity which is useful for protecting the body from various types of cancer. One of the hydrocolloids that is widely used is gum arabic. The application of gum arabic improve the flexibility of the fruit leather, more than other stabilizers, such as maltodextrin, pectin, and CMC. Gum arabic also well known as the best hydrocolloid to maintain the quality of the fruit leather [9]. Based on these findings, the role of gum arabic as a gelling agent in fruit leather production was observed.

put it in the cabinet dryer, then dried it at 50 °C for 24 hours. The flow chart of the fruit leather processing is drawn in Figure 1.

2.4 Fruit Leather Analysis

The quality of starfruit-red guava fruit leather was determined based on physical, chemical, microbiological, and sensory properties. The physical properties was represented by tensile strength values [11]. The chemical properties being analyzed included water content [12], ash content [13], vitamin C content [12], crude fiber content [14], pH value [14], and water activity value [15]. The microbiological properties being analyzed included total bacteria [16] and total yeast and mold [17], while the sensory properties included the hedonic test [18] and hedonic quality test [18] for the parameters of color, aroma, flavor, and texture.

2.0 METHODOLOGY

The process of starfruit (var. Dewa) and red guava fruit leather refers to [1] and [10] which consists of making puree and making fruit leather.

2.1 Producing Starfruit Puree

The starfruit used was a mix maturity type of starfruits, i.e., ripe and half-ripe starfruit with a ratio of 2 : 1. The starfruit was washed by clean water and then blanched at 80°C for 15 minutes. The blanched starfruits were cut into small pieces with size of ± 2 x 2 cm, then crushed in a Turbo blender with speed of 1 for 2 minutes (modification [1] and [10]).

2.2 Producing Red Guava Puree

The red guava fruits used were the mix of ripe and half-ripe red guava with a ratio of 2 : 1. Furthermore, the red guava fruits were washed by clean water and then blanched at 80°C for 15 minutes. The blanched red guava fruits were cut into small pieces with a size of ± 2 x 2 cm, then crushed with a Turbo blender with speed of 1 for 2 minutes with the ratio of fruit and water 1 : 1. The puree of red guava was then filtered.

2.3 Producing Fruit Leather

Starfruit and red guava purees were mixed according to the designed formulation. In this study, five formulas were developed. Basically, each formula contain similar components, i.e. 83% starfruit puree, 9% red guava puree, 8% sorbitol, and 0.05% citric acid. Gum arabic was applied to the formulas in various level, namely 0%, 0.5%, 1%, 2%, and 2.5% (Based on the previous study). Then the mixture was stirred manually until all the ingredients were mixed and heated at 70°C for 2 minutes. Cooked mixture (400 ml) was then poured into an aluminium pan (29.5 cm x 20.5 cm x 1 cm) which has been coated with baking paper. Then,

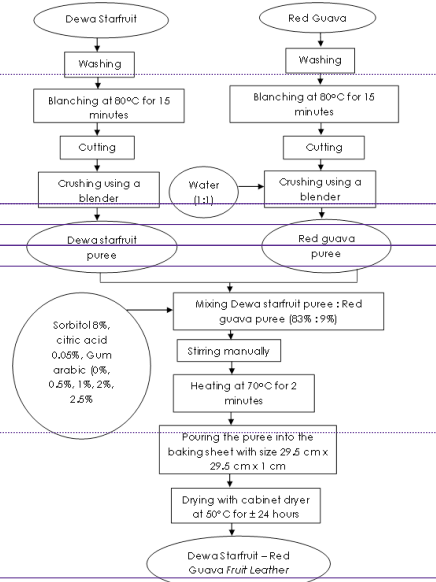


Figure 1 Production process of Dewa starfruit-red guava fruit leather (modification [1])

2.5 Data Analysis Technique

The resulted data were analysed using single factor analysis of variance (ANOVA) with three replications. Any significant difference of the treatment (gum arabic concentration) were followed by further Duncan's Multiple Range Tests (DMRT) at 95% confidence level.

3.0 RESULT AND DISCUSSION

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Deleted: fruit used is Dewa starfruit quality C, because it is not optimally used, while usually for producing juice and dodol, and is not sold in fresh because of its small size, which is ± 150 g / fruit. However, in terms of taste and aroma, starfruit quality C has the same taste and aroma as starfruit quality A and quality B. In order to improve the the quality of Dewa Starfruit ...he produced fruit leather, it is formulated with red guava, which is also grows a lot in the city of Depok. According to ... [1]

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The quality of the Dewa starfruit-red guava fruit leather includes physical qualities (tensile strength test), chemical qualities (water, ash, crude fiber, vitamin C contents, pH, water activity value (aw)), microbiological qualities (the total bacteria and total mold-yeast test), and also the sensory analysis (the hedonic and quality test for the parameters of color, aroma, texture, and flavor). The characteristic observations have been made on the produced fruit leather. The results are presented in Table 1 and 2.

The tensile strength value of the fruit leather ranged from 294.12 to 553.75 gf. Table 1 showed that the tensile strength value increased with the increasing of the gum arabic concentration. The ANOVA showed that the addition of different gum arabic concentrations had a significantly different effect ($p < 0.05$) on the tensile strength value of the fruit leather. Tensile strength is calculated based on the force required to stretch the fruit leather until it breaks [11].

3.1 Tensile Strength Value

Table 1 Physicochemical and microbiological characteristics of Dewa starfruit - red guava fruit leather

Quality Parameters	Gum arabic concentration				
	0%	0.5%	1%	2%	2.5%
Tensile strength value (gf)	294.12±29.35 ^a	437.38±75.10 ^{ab}	465.60±71.82 ^b	467.90±93.72 ^b	553.75±80.27 ^b
Water content (%)	7.63 ± 0.44 ^a	7.38 ± 0.43 ^a	7.62 ± 0.29 ^a	7.17 ± 0.22 ^{ab}	6.63 ± 0.31 ^b
Ash content (%)	1.88 ± 0.13 ^a	2.02 ± 0.02 ^b	2.07 ± 0.01 ^{bc}	2.14 ± 0.01 ^{cd}	2.18 ± 0.01 ^d
Crude fiber content (%)	1.78 ± 0.09	1.85 ± 0.10	2.09 ± 0.32	2.11 ± 0.41	2.32 ± 0.17
Vitamin C content (mg/100g)	76.91 ± 1.19 ^a	77.08 ± 1.22 ^a	77.61 ± 2.35 ^a	82.96 ± 0.25 ^b	86.53 ± 0.53 ^c
pH content	4.16 ± 0.05 ^a	4.22 ± 0.03 ^{ab}	4.23 ± 0.04 ^b	4.25 ± 0.02 ^{bc}	4.31 ± 0.03 ^c
Water activity content	0.49 ± 0.03	0.48 ± 0.02	0.46 ± 0.02	0.46 ± 0.03	0.44 ± 0.00
Total bacteria (CFU/g)	<2.5	<2.5	<2.5	<2.5	<2.5
Total yeast and mold (CFU/g)	<1	<1	<1	<1	<1

Notes : Values with different superscript letters are significantly ($p < 0.05$) different

In this research, gum arabic acts as a gelling agent. Gel formation is a process of the cross-linking of polymer chains to form a continuous three-dimensional network capable of trapping liquids, forming a rigid and sturdy texture [19]. This caused the fruit leather to be difficult to break because it required a large amount of energy to break these cross-links. Patil *et al.* [20] also stated that a denser fruit leather structure requires more energy to break down the fruit leather so that it can be swallowed. Thus, the higher the concentration of gum arabic, the higher tensile strength value of the starfruit-red guava fruit leather. This is in accordance with [1] where the addition of the higher concentration of gum arabic on the fruit leather of banana caused an increase in the value of tensile strength. Fruit leather which has high tensile strength has better resistance to tensile forces so that it is not easily broken and torn [21].

One of the quality characteristics of fruit leather is that it has an elastic texture. The use of hydrocolloids is important to maintain the desired texture of the fruit leather. Hydrocolloid is used as a gelling agent which is able to bind water molecules thereby increasing the texture properties of the desired food material [22]. Al-Hinai *et al.* [23] also studied that the hardness level of the fruit leather dates increased with increasing concentrations of hydrocolloids used.

3.2 Water content

The water content of starfruit-red guava fruit leather shown in Table 1 was ranged from 7.63 to 6.63 percent. Table 1 showed that the water content of fruit leather relatively decreased as the gum arabic concentration was higher. The ANOVA result showed that the addition of gum arabic with different concentrations had significant effect ($p < 0.05$) on the water content in fruit leather.

Gum Arabic is a hydrocolloid which is used as a gelling agent. The presence of a large number of hydroxyl (-OH) groups in the hydrocolloid can increase its affinity to bind water molecules to make it a hydrophilic compound. Gel formation is the formation of cross-linked polymer chains to form a three-dimensional network that can trap water in it to form rigid structures [24]. Therefore the amount of free water and adsorbed water in the fruit leather decreased. The higher the gum arabic concentration made the higher the amount of water absorbed, so that the water content in the fruit leather decreased. Lower water content in the fruit leather is a favorable condition because microorganisms are difficult to live and can extend shelf life. Suna *et al.*, (2014) [25] showed that water content of fruit leather below 15% can prevent microbial growth. Overall, the water content of the fruit leather, starfruit, red guava still meets the SNI No. 1718-1996 regarding dried candied fruit, which states that the maximum moisture content of dried candied fruit is 25% [26].

3.3 Ash Content

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The ash content of the Dewa starfruit-red guava fruit leather ranged from 1.88 to 2.18 percent. Table 1 showed that the ash content of fruit leather increased as the gum arabic concentration was higher. The ANOVA results showed that the addition of gum arabic with different concentrations had a significant effect ($p < 0.05$) on the ash content of the fruit leather.

The difference in the ash content of the fruit leather is due to the presence of several minerals in gum arabic, namely 0.17% of calcium, 3.90% of magnesium, 0.00004% of iron, 0.0004% of sodium, and 2.07% of potassium. Yebeyen et al. (2009) [27] reported availability of several minerals in gum arabic, such as calcium, magnesium, iron, sodium, phosphorus, potassium, and non detectable traces of Pb, Co, Cu, Zn, Ni, Cd, Cr, and Mn. The gum arabic used in this research is gum arabic that grows in Sudan, while the gum arabic used in [27] grows in Ethiopia. Thus it produced a different mineral content.

3.4 Crude Fiber Content

The crude fiber content of the Dewa starfruit-red guava fruit leather ranged from 1.78 to 2.32 percent. Table 1 showed that the crude fiber content of the fruit leather increased as the gum arabic concentration was higher. The ANOVA results showed that the addition of different concentrations of gum arabic did not have a significant effect ($p > 0.05$) on the crude fiber content of the fruit leather.

The increase in crude fiber content of fruit leather was due to the presence of soluble and insoluble dietary fiber in Arabic gum. In Arabic gum used, there are 76.20 mg of soluble dietary fiber and 13 mg of insoluble dietary fiber in 150 g of gum arabic, meaning that the concentration of gum arabic can increase fruit leather fiber content. This is in line with [28] that the addition of gum arabic can increase the amount of dietary fiber, because there was 78,099% of dietary fiber in gum arabic. The difference in fiber content is probably due to the different variants of gum arabic used. The gum arabic used in this study was a senegalese variant of gum arabic, while the gum arabic used in [28] was a kerensis variant of gum arabic. So that it produced different fiber content.

According to the Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2019, concerning the Recommended Nutritional Adequacy Rate (RDA) for the Indonesian people, the recommended amount of fiber per person per day ranges from 11-23 g for the age group of infants and children, 22-37 g for the male 10-80 years old group, and 20-32 g for the 10-80 year old female age group. The crude fiber content of Dewa-red guava fruit leather ranges from 1.78% - 2.32%. So it can be said that 1 roll of fruit leather as much as 2 g can meet the nutritional adequacy rate of fiber of 0.2 - 0.5% for the category of infants and children, 0.14-0.23% for the male age group 10-80 years old, and 0.16-0.25% for the female age group 10-80 years old.

3.5 Vitamin C Content

The vitamin C content of Dewa starfruit-red guava fruit leather ranged from 76.91 to 86.53 mg / 100g. Table 1 showed that the vitamin C content of fruit leather increased as the gum arabic concentration was higher. The ANOVA results showed that the addition of gum arabic with different concentrations had a significant effect ($p < 0.05$) on the vitamin C content of the fruit leather. Gum arabic is a hydrocolloid that can form a gel so that it can protect vitamin C from oxidative damage [29]. Silalahi et al., [30] also said that gum arabic also has the ability to inhibit the oxidation process. Therefore, the higher the concentration of gum arabic added, the higher the levels of vitamin C fruit leather.

According to the Regulation of the Minister of Health of the Republic of Indonesia, concerning the recommended nutritional adequacy rate (RDA) for the Indonesian people, the recommended amount of vitamin C per person per day ranges from 40 - 45 mg for the age group of infants and children, 50 - 90 mg for the male age group, and 50-75 mg for the female age group [31]. Vitamin C content of Dewa starfruit-red guava fruit leather ranged from 76.91 to 86.53 mg / 100 g. So it can be stated that 1 roll of fruit leather as much as 2 g can met the nutritional adequate rate of vitamin C as much as 4% for the category of infants and children, 2-3% for the male age group 10-80 years old, and 2% for the female age group 10-80 years old.

3.6 pH Value

The pH value of the fruit leather ranged from 4.16 - 4.31. Table 1 showed that the pH value of the fruit leather increased with increasing concentration of gum arabic. The ANOVA results showed that the addition of different Arabic gum concentrations had a significant effect ($p < 0.05$) on the pH value of the fruit leather. Gum Arabic has the ability to bind water and water has properties to bind organic acids. So that the higher the concentration of gum arabic, the more water is bound, and organic acids are bound by water [32]. Therefore, the measured amount of free organic acid is less. A low acid concentration can be indicated by a high pH value.

The pH value of the fruit leather ranged from 4.16 to 4.31 which indicated that this fruit leather is a acid food. Acid food is defined as a food with a pH value of 4.60 or lower [33]. Lower pH in fruit leather would be advantageous because it would not be support growth of disease-causing bacteria. According to his research [34], gum arabic dissolves at acidic pH. Ref [35] states that gum arabic can reach a maximum viscosity at pH 3.9 - 4.9. This pH condition will help form the colloidal properties of the fruit leather solution, so that the fruit leather sheets can be formed properly.

The pH value of the fruit leather starfruit-red guava ranged from 4.16 - 4.31 which indicated that this fruit leather was an acidic food. Acidic foods are defined as foods that have a pH value of

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4.60 or lower than 4.60 [33]. Low pH value in the fruit leather is a favorable condition, because this condition will not support the growth of disease-causing bacteria. According to Hutapea [34], gum arabic is soluble at acidic pH, while [35] stated that gum arabic can reach a maximum viscosity at pH 3.9 - 4.9. This pH condition will help to form the colloidal properties of the fruit leather solution, so that fruit leather sheets can be formed properly.

3.7 Water Activity Value

The water activity value of fruit leather ranged from 0.44 to 0.49. Table 1 showed that the water activity value of fruit leather relatively decreased with the increased in gum arabic concentration. The ANOVA results showed that the addition of different gum arabic concentrations did not have a significant effect ($p > 0.05$) of the water activity (aw) value of the fruit leather. Water activity is the amount of free water in food materials that can be used for the growth of microorganisms. The decrease in the value of water activity was associated with the decrease in water content, indicating the decrease amount of free water which required for microorganism activity. Water that evaporated during the drying process is included in the free water group which is not strongly bound [36].

Water activity can predict the types of microorganisms that can live and have the potential to become a source of decay and infection. The value of water activity on the fruit leather was lower than the aw value for the growth needs of bacteria, molds and yeasts. Pathogenic microorganisms could not grow at $aw < 0.86$, while molds and yeasts were more tolerant of these conditions. Wherein the mold and yeast did not grow at $aw < 0.62$ [37]. The relatively small value of water activity in fruit leather products can inhibit the growth of bacteria, mold, and yeast. However, the aw value of 0.44-0.49 in fruit leather still allowed to lipid oxidation, non-enzymatic browning, and enzyme activity.

3.8 Total Bacteria Value

The total bacteria value of fruit leather indicated that the bacterial growth less than 2.5 CFU / g. According to the Bacteriological Analytical Manual [16], the conditions for the plates that can be counted are 25 to 250 colonies. However, based on the results shown in Table 1, the resulting bacterial colonies were less than 25, so the data obtained could not be analyzed by ANOVA.

According to SNI 7388 : 2009 [38], the maximum standard limit for microbial contamination of dried fruit sweets for total bacteria is 1×10^5 colonies / g.

Based on the total results of the fruit leather bacteria, it can be stated that the total bacterial Dewa starfruit-red guava fruit leather still meets the standard of dried fruit sweets. The total value of bacteria obtained is relevant with the result of aw fruit leather value, which is less than 0.9, so that this condition can inhibit the growth of bacteria in the Dewa starfruit-red guava fruit

leather product. Low water content and pH value can also inhibit microbial growth and extend shelf life, which further affected the health of consumers [39].

Based on this, gum arabic has an effect in reducing the pH of the Dewa starfruit-red guava fruit leather, so that low pH conditions can inhibit the growth of microorganisms. This was in line with the effect of gum arabic in reducing the water content of the fruit leather, which showed the decreasing amount of free water required for microorganism activity.

3.9 Total Yeast and Mold Value

The total yeast and mold value of fruit leather indicates the growth of yeast and mold less than 1.0 CFU/g. According to the Bacteriological Analytical Manual [17], the requirements for the plates that can be counted are 10 to 150 colonies. However, based on the results shown in Table 1, the resulting yeast and mold colonies were less than 10, so the data obtained could not be analyzed by ANOVA.

According to SNI 7388 : 2009 [38], the maximum standard limit for microbial contamination of dried fruit sweets for total yeast and mold were 5×10^1 colonied/g. Based on the results of the total yeast and mold, it can be stated that the total yeast and mold of Dewa starfruit-red guava fruit leather still met the standard of dried fruit sweets. The total value of yeast and mold obtained relevant with the aw value fruit leather that is produced, which is less than 0.6 will inhibit the growth of yeast and mold in the products of Dewa starfruit-red guava fruit leather. These results were expected since fruit leathers had low pH and low water content. Thus this fruit leather was expected to have a stable shelf-life for several months. Similar results of microbial stability of fruit leather are also reported in guava papaya fruit leather, the growth of microorganism were also well within the safe limit for consumption till 4 months of storage period [40].

Based on the research results, gum arabic has an effect in reducing the pH of the Dewa starfruit-red guava fruit leather, so that low pH conditions can inhibit the growth of microorganisms. This is in line with the effect of gum arabic in reducing the water content of the fruit leather, which shows the decreasing amount of free water required for microorganism activity.

3.10 Sensory Test

The sensory test of the Dewa starfruit-red guava fruit leather includes the hedonic test and the hedonic quality for the parameters of color, aroma, texture, and flavor. The results of the fruit leather sensory test are presented in Table 2.

3.10.1 Color

Color, an important attribute in food products, can be assessed either by a sensory panel [41]. The score value of color on fruit leather ranged from

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3.0 to 3.5 (golden yellow - orange) with acceptance value ranged from 3.7 - 3.8 (like). The ANOVA results showed that the addition of

gum arabic with different concentrations had a significant effect ($p < 0.05$) on the score value of color on the fruit leather.

Table 2 Sensory test of Dewa starfruit - red guava fruit leather

Concentration of gum arabic	Parameters	Attributes			
		Color	Starfruit Aroma	Starfruit Taste	Texture
0%	Score	3.0 ± 0.08 ^a	2.5 ± 0.08	3.5 ± 0.03	3.5 ± 0.08 ^a
	Acceptance	3.8 ± 0.06	3.6 ± 0.08	3.9 ± 0.03	3.6 ± 0.03 ^{ab}
0.5%	Score	3.1 ± 0.06 ^{ab}	2.7 ± 0.05	3.5 ± 0.08	3.6 ± 0.05 ^a
	Acceptance	3.8 ± 0.12	3.6 ± 0.10	3.9 ± 0.09	3.6 ± 0.05 ^b
1%	Score	3.3 ± 0.05 ^b	2.7 ± 0.16	3.5 ± 0.10	3.7 ± 0.03 ^b
	Acceptance	3.8 ± 0.06	3.6 ± 0.08	3.8 ± 0.03	3.8 ± 0.05 ^c
2%	Score	3.5 ± 0.05 ^c	2.7 ± 0.12	3.5 ± 0.03	2.6 ± 0.10 ^c
	Acceptance	3.8 ± 0.06	3.6 ± 0.12	3.9 ± 0.05	3.7 ± 0.03 ^c
2.5%	Score	3.5 ± 0.14 ^c	2.8 ± 0.36	3.5 ± 0.08	2.7 ± 0.08 ^c
	Acceptance	3.7 ± 0.06	3.6 ± 0.08	3.8 ± 0.03	3.5 ± 0.05 ^a

Score description:

Score : **Color** : 1 (light yellow) ; 2 (yellow) ; 3 (golden yellow) ; 4 (orange) ; 5 (red). **Starfruit Aroma** : 1 (not very strong) ; 2 (not strong) ; 3 (slightly strong) ; 4 (strong) ; 5 (very strong). **Starfruit Taste** : 1 (not very strong) ; 2 (not strong) ; 3 (slightly strong) ; 4 (strong) ; 5 (very strong). **Texture** : 1 (very inelastic) ; 2 (not elastic) ; 3 (slightly elastic) ; 4 (elastic) ; 5 (very elastic)

Acceptance : 1 (very dislike) ; 2 (dislike) ; 3 (rather like) ; 4 (like) ; 5 (very like)

The yellow color of the fruit leather indicated the presence of β -cryptoxanthin which is a color pigment in starfruit [42]. While the orange color in the fruit leather is the result of a combination of yellow pigments in star fruit and red pigments in red guava. According to [43], red guava has carotenoid compounds, especially lycopene pigments of 6900 $\mu\text{g}/100\text{ g}$ and β -carotene of 430 $\mu\text{g}/100\text{ g}$ [44]. According to [45], the dehydration process can change the surface characteristics of food, as well as its color and reflectance. Chemical changes in pigments such as carotene and chlorophyll are produced by heat and oxidation that occurs during drying. In general, the longer the processing time and the higher the temperature, the greater the loss of the pigment.

Fruit leather with a concentration of 0% gum arabic has a golden yellow color, while the color of fruit leather with a concentration of 2.5% gum arabic tends to be reddish yellow (orange), which means it was darker than the color of the fruit leather without the addition of gum arabic. This is supported by [11] which stated that the level of preference for panelists to the color of jackfruit fruit leather decline along with the higher concentration of gum arabic. The color change is caused by the Maillard reaction. The Maillard reactions in fruit leather is possibly caused by the presence of proteins contained in gum arabic. Apart from the protein content, gum arabic also contains monosaccharide molecules which act as reducing sugars [11].

3.10.2 Aroma

The value of the aroma quality assessed from the Dewa starfruit-red guava fruit leather is the intensity of the starfruit aroma. Table 2 showed that the value of the fruit leather aroma ranged from 2.5 to 2.8 (rather strong), which indicated that the scent of starfruit from the fruit leather was rather strong, with a acceptance value was 3.6 (like). The

ANOVA result showed that the addition of gum arabic with different concentrations did not have significant effect ($\alpha = 0.05$) to the value of the score aroma of fruit leather.

According to [47], gum arabic is odorless when consumed by humans, so the addition of gum arabic did not affect the aroma of fruit leather. This is reinforced by [48], that hydrocolloids do not contain volatile ingredients which can cause aroma and color to food ingredients. The value of score aroma that is assessed from the Dewa starfruit-red guava fruit leather is the intensity of the starfruit aroma. According to [49], there were fifty-six volatile components in starfruit identified (8.9 mg/kg), the main ones being butyl acetate, ethyl decanoic and hexadecanoic acid.

3.10.3 Taste

The value of the taste quality assessed from the Dewa starfruit-red guava fruit leather is the intensity of the starfruit taste. Table 2 showed that the value of the fruit leather taste is 3.5 (strong) which indicated that the taste of starfruit from the fruit leather was strong, with a acceptance value ranged from 3.8 to 3.9 (likes). The ANOVA results showed that the addition of gum arabic with different concentrations did not have a significant effect ($p > 0.05$) to the value of the score taste of fruit leather. It caused of gum arabic has no taste, so the taste produced by the Dewa starfruit-red guava fruit leather is the original taste of starfruit. Similar results of their research that the addition of gum arabic did not affect the taste of the product [50].

3.10.4 Texture

The value of the score texture assessed from the Dewa starfruit-red guava fruit leather was the intensity of the fruit leather elasticity. Table 2 showed that the value of the fruit leather texture

ranged from 2.6 (slightly elastic) to 3.5 (elastic), with a acceptance value ranged from 3.5 to 3.8 (like). The ANOVA results showed that the addition of gum arabic with different concentrations had significant effect ($p < 0.05$) to the value of the score texture of fruit leather.

Texture is an important parameter in determining the quality of the fruit leather. The texture produced by the fruit leather is influenced by the type and concentration of hydrocolloids [51] [52]. The texture parameter tested on the panelists is the level of elasticity of the fruit leather. The elasticity level of the fruit leather increased until the addition of 1% gum arabic, but decreased in the addition of 2% and 2.5% gum arabic. The decrease in the elasticity of the fruit leather possibly caused by the concentration of gum arabic that is too high.

In this research, gum arabic act as a gelling agent. Gel formation is a process of cross-linking polymer chains to form a continuous three-dimensional network capable of trapping liquids, forming a rigid and sturdy texture [19]. This made the fruit leather difficult to break because it required a large amount of energy to break these cross-links. Thus the higher concentration of gum arabic, then the more water was bound by gum arabic, so that the amount of free water contained in the material decreased, as a result the fruit leather water content was lower. This caused a decrease in the level of elasticity of the fruit leather [53].

The decrease in the level of elasticity of the fruit leather was also caused by the increase in the tensile strength value along with the increasing concentration of gum arabic. This is relevant with [54]. Rahmanto et al. [54] studied the jackfruit fruit leather which showed that the increasing the concentration of gum arabic, the resulting decreased water content of the fruit leather, which caused the texture of fruit leather tight and less elastic. The addition of gum arabic with a 0.9 % w/w was too high and caused the texture of the fruit leather was tough, dry texture, and difficult to chew. This statement is directly proportional to the water content of the Dewa starfruit-red guava fruit leather relative decline with the concentration of gum arabic. Siburian and Dahang [55] also stated that high water content will produce a soft texture indicated by a lower texture value. Therefore, there is optimum limit to use a gum arabic to produce the desire texture of fruit leather.

4.0 CONCLUSION

1. The addition of gum arabic at different concentrations in produced fruit leather from starfruit-red guava was significantly different at $\alpha = 0.05$ on the parameters of tensile strength, water content, ash content, vitamin C content, pH value, hedonic quality value of color, hedonic value and hedonic quality value of texture. However, there is no significant effect on crude fiber content, water activity value,

hedonic value of color, hedonic value and hedonic quality value of aroma, as well as hedonic value and quality hedonic value of flavor.

2. Fruit leather which produces the best quality is the fruit leather with the addition of 0.5% gum arabic with the parameters of the tensile strength value of 437.38 gf, water content of 7.38%, ash content of 2.02%, vitamin C content of 77.08 mg / 100 g, crude fiber content of 1.85, pH value of 4.22, water activity value of 0.48, total bacteria value of <2.5 CFU/g, total yeast and mold value of <1 CFU/g, with golden yellow color, slightly strong starfruit aroma, strong star fruit flavor, and elastic fruit leather texture. In addition, 1 roll of fruit leather as much as 2 grams can meet the nutritional adequacy rate of vitamin C by 4% for the infant and child category, 2-3% for the male age group 10-80 years, and 2% for the 10-80 years, and can meet the nutritional adequacy rate of fiber of 0.2 - 0.5% for the category of infants and children, 0.14-0.23% for the male age group 10-80 years, and 0.16-0.25% for the 10-80 year age group for women.

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CHARACTERISTIC OF DEWA STARFRUIT-RED GUAVA FRUIT LEATHER DUE TO THE ADDITION OF GUM ARABIC

Authors 2021

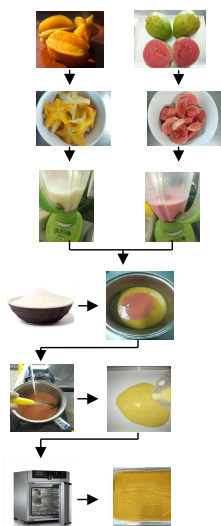
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Graphical abstract



Abstract

Fruit leather is one of the processed fruit products. Its shape similar to a thin sheet that can be rolled, has an elastic texture, and has a specific flavour. One of the suitable fruit that can be processed to fruit leather is starfruit and red guava. The aim of this research was to study the characteristics of the fruit leather made from starfruit Dewa variety and red guava which were added with Arabic gum with different concentration (0%, 0.5%, 1%, 2%, and 2.5%). Data were analyzed by analysis of variance (ANOVA) at $\alpha = 0.05$. The result showed that the addition of Arabic gum had a significant effect on tensile strength, water, ash, vitamin C content, and pH value, but it did not has a significant effect on crude fiber, water activity content, total bacteria, and total yeast and mold. While the addition of Arabic gum had a significant effect on color and texture sensory test. The best fruit leather was determined based on the physicochemical and sensory test, and it showed that the addition of 0.5% Arabic gum was the best. Characteristics of the best starfruit and guava fruit leather were tensile strength value 437.38 gf, water content 7.38%, ash content 2.02%, vitamin C content 77.08%, crude fiber content 1.85%, pH value 4.22, water activity value 0.48, total bacteria < 2.5 CFU/g, total yeast and mold < 1 CFU/g with golden yellow color, slightly strong starfruit aroma, strong starfruit flavor, and elastic fruit leather texture.

Keywords: Arabic gum, Dewa starfruit, fruit leather, physicochemical properties, red guava, and sensory properties

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1.0 INTRODUCTION

Fruit leather is a fruit preserved product that is growing rapidly in various countries in the world [1] which can be consumed as candy or snacks [2]. Fruit leather is made from drying fruit puree to form a thin sheet that can be rolled with a thickness of 2 - 3 mm, contains 10-20% water, has a plastic texture, and has a specific consistency and flavor according to the type of fruits used [1].

In Indonesia, fruit leather is not widely known, but several studies have been conducted on processed fruit leather from various kinds of fruit, such as apple fruit leather [2], red guava fruit leather [3], papaya fruit leather [4], and others. Currently, in Indonesia, fruit leather is not yet popular. Therefore, the Dewa starfruit fruit leather will be made, due to it is one of the best starfruit variety in Indonesia and the world, which has become an icon of Depok city and is a local resource for the city of Depok [5]. In addition, the

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making of Dewa starfruit fruit leather is expected to be an alternative for souvenirs of Depok City. The fruit used is Dewa starfruit quality C, because it is not optimally used, while usually for producing juice and dodol, and is not sold in fresh because of its small size, which is ± 150 g / fruit. However, in terms of taste and aroma, starfruit quality C has the same taste and aroma as starfruit quality A and quality B. In order to improve the quality of Dewa Starfruit fruit leather, it is formulated with red guava which is also grows a lot in the city of Depok. According to [6], red guava is rich in vitamin C (64.69 mg / 100 g of material), has a higher pectin content than starfruit (4.1%) [7] [8]. In red guava, carotenoids are also found which have antioxidant activity which is useful for protecting the body from various types of cancer. In making fruit leather, hydrocolloids are still needed to help gel formation. One of the hydrocolloids that is widely used is gum arabic. Gum arabic can improve the flexibility of the fruit leather better than other stabilizers such as maltodextrin, pectin, and CMC, and it is the best hydrocolloid used to maintain the quality of the fruit leather [9]. Based on this, it will be researched the fruit leather, with the addition of gum arabic as a gelling agent.

2.0 METHODOLOGY

The process of making Dewa starfruit and red guava fruit leather refers to [1] and [10] which consists of making puree and making fruit leather.

2.1 Producing Starfruit Puree

The starfruits used were a combination of ripe and half-ripe starfruit with a ratio of 2 : 1. Furthermore, the starfruits were washed by clean water and then blanched at 80°C for 15 minutes. Then, the blanched starfruits were cut into small pieces with size of $\pm 2 \times 2$ cm, then crushed in a Turbo blender with speed of 1 for 2 minutes (modification [1] and [10]).

2.2 Producing Red Guava Puree

The red guava fruits used were the combination of ripe and half-ripe red guava with a ratio of 2 : 1. Furthermore, the red guava fruits were washed by clean water and then blanched at 80°C for 15 minutes. The blanched red guava fruits were cut into small pieces with a size of $\pm 2 \times 2$ cm, then crushed with a Turbo blender with a speed of 1 for 2 minutes with the ratio of fruit and water 1 : 1. After that, the puree of red guava was filtered.

2.3 Producing Fruit Leather

Starfruit puree and red guava puree were mixed according to the formulation. In this study, there were five formulations. In each formulation, there were 83% starfruit puree, 9% red guava puree, 8% sorbitol, 0.05% citric acid, and gum arabic with different concentrations in each formulation,

namely 0%, 0.5%, 1%, 2%, and 2.5% (Based on the previous study). Then the mixture was stirred manually until all the ingredients were mixed and heated at 70°C for 2 minutes. After the mixture was cooked, it was poured as much as 400 ml into the aluminium pan measuring 29.5 cm x 20.5 cm x 1 cm which has been coated with baking paper. Then, put it in the cabinet dryer, then dried it at 50 °C for 24 hours. The flow chart of the producing of Dewa starfruit-red guava fruit leather can be seen in Figure 1.

2.4 Fruit Leather Analysis

The quality of Dewa starfruit-red guava fruit leather was determined based on physical, chemical, microbiological, and sensory properties. The physical properties of the fruit leather analyzed was tensile strength values [11]. The chemical properties of the fruit leather being analyzed included water content [12], ash content [13], vitamin C content [12], crude fiber content [14], pH value [14], and water activity value [15]. The microbiological properties of the fruit leather being analyzed included total bacteria [16] and total yeast and mold [17], and the sensory properties of the fruit leather being analyzed included the hedonic test [18] and hedonic quality test [18] for the parameters of color, aroma, flavor, and texture.

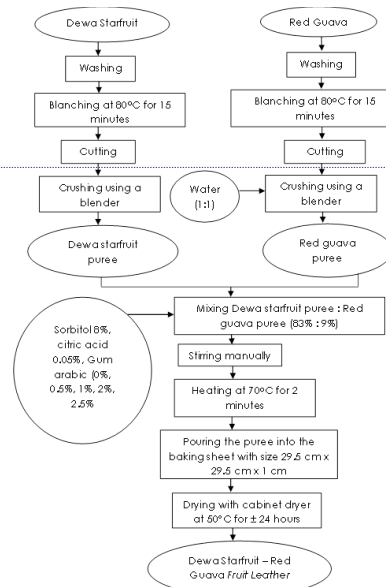


Figure 1 The flow chart of the making of Dewa starfruit-red guava fruit leather (modification [1])

2.5 Data Analysis Technique

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The analysis technique used was a single factor analysis of variance (ANOVA) with three replicates. If there was a significant difference between gum arabic concentration, a further Duncan's multiple range tests (DMRT) is performed at 95% confidence level.

3.0 RESULT AND DISCUSSION

The quality of the Dewa starfruit-red guava fruit leather includes physical qualities (tensile strength test), chemical qualities (water, ash, crude fiber, vitamin C contents, pH, water activity value (aw)), microbiological qualities (the total bacteria and total mold-yeast test), and also the sensory analysis (the hedonic and quality test for the parameters of color, aroma, texture, and

flavor). The results of the fruit leather qualities test are presented in Table 1 and 2.

3.1 Tensile Strength Value

The tensile strength value of the Dewa starfruit-red guava fruit leather shown in Table 1 ranged from 294.12 to 553.75 gf. Table 1 showed that the tensile strength value increased with the increasing of the gum arabic concentration. The ANOVA results showed that the addition of different gum arabic concentrations had a significantly different effect ($p < 0.05$) on the tensile strength value of the fruit leather. Tensile strength is calculated based on the force required to stretch the fruit leather until it breaks [11].

Table 1 Physicochemical and microbiological characteristics of Dewa starfruit - red guava fruit leather

Quality Parameters	Gum arabic concentration				
	0%	0.5%	1%	2%	2.5%
Tensile strength value (gf)	294.12±29.35 ^a	437.38±75.10 ^{ab}	465.60±71.82 ^b	467.90±93.72 ^b	553.75±80.27 ^b
Water content (%)	7.63 ± 0.44 ^a	7.38 ± 0.43 ^a	7.62 ± 0.29 ^a	7.17 ± 0.22 ^{ab}	6.63 ± 0.31 ^b
Ash content (%)	1.88 ± 0.13 ^a	2.02 ± 0.02 ^b	2.07 ± 0.01 ^{bc}	2.14 ± 0.01 ^{cd}	2.18 ± 0.01 ^d
Crude fiber content (%)	1.78 ± 0.09	1.85 ± 0.10	2.09 ± 0.32	2.11 ± 0.41	2.32 ± 0.17
Vitamin C content (mg/100g)	76.91 ± 1.19 ^a	77.08 ± 1.22 ^a	77.61 ± 2.35 ^a	82.96 ± 0.25 ^b	86.53 ± 0.53 ^c
pH content	4.16 ± 0.05 ^a	4.22 ± 0.03 ^{ab}	4.23 ± 0.04 ^b	4.25 ± 0.02 ^{bc}	4.31 ± 0.03 ^c
Water activity content	0.49 ± 0.03	0.48 ± 0.02	0.46 ± 0.02	0.46 ± 0.03	0.44 ± 0.00
Total bacteria (CFU/g)	<2.5	<2.5	<2.5	<2.5	<2.5
Total yeast and mold (CFU/g)	<1	<1	<1	<1	<1

Notes : Values with different superscript letters are significantly ($p < 0.05$) different

In this research, gum arabic acts as a gelling agent. Gel formation is a process of the cross-linking of polymer chains to form a continuous three-dimensional network capable of trapping liquids, forming a rigid and sturdy texture [19]. This caused the fruit leather to be difficult to break because it required a large amount of energy to break these cross-links. Patil *et al.* [20] also stated that a denser fruit leather structure requires more energy to break down the fruit leather so that it can be swallowed. Thus, the higher the concentration of gum arabic, the tensile strength value of the Dewa starfruit-red guava fruit leather increased. This is in accordance with [1] where the addition of the higher concentration of gum arabic on the fruit leather of banana caused the value of tensile strength increased. Fruit leather which has high tensile strength, has better resistance to tensile forces so that it is not easily broken and torn [21].

One of the quality characteristics of fruit leather is that it has an elastic texture. The use of hydrocolloids is important to maintain the desired texture of the fruit leather. Hydrocolloid is used as a gelling agent which is able to bind water molecules thereby increasing the texture properties of the desired food material [22]. Al-Hinai *et al.*, [23] also studied that the hardness level of the fruit leather dates increased with increasing concentrations of hydrocolloids used.

3.2 Water content

The water content of the Dewa starfruit-red guava fruit leather shown in Table 1 ranged from 7.63 to 6.63 percent. Table 1 showed that the water content of fruit leather relatively decreased as the gum arabic concentration was higher. The ANOVA result showed that the addition of gum arabic with different concentrations had significant effect ($p < 0.05$) on the water content in fruit leather.

Gum Arabic is a hydrocolloid which is used as a gelling agent. The presence of a large number of hydroxyl (-OH) groups in the hydrocolloid can increase its affinity to bind water molecules to make it a hydrophilic compound. Gel formation is the formation of cross-linked polymer chains to form a three-dimensional network that can trap water in it to form rigid structures [24]. Therefore the amount of free water and adsorbed water in the fruit leather decreased. The higher the gum arabic concentration made the higher the amount of water absorbed, so that the water content in the fruit leather decreased. Lower water content in the fruit leather is a favorable condition because microorganisms are difficult to live and can extend shelf life. Suna *et al.*, (2014) [25] showed that water content of fruit leather below 15% can prevent

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microbial growth. Overall, the water content of the fruit leather, starfruit, red guava still meets the SNI No. 1718-1996 regarding dried candied fruit, which states that the maximum moisture content of dried candied fruit is 25% [26].

3.3 Ash Content

The ash content of the Dewa starfruit-red guava fruit leather ranged from 1.88 to 2.18 percent. Table 1 showed that the ash content of fruit leather increased as the gum arabic concentration was higher. The ANOVA results showed that the addition of gum arabic with different concentrations had a significant effect ($p < 0.05$) on the ash content of the fruit leather.

The difference in the ash content of the fruit leather is due to the presence of several minerals in gum arabic, namely 0.17% of calcium, 3.90% of magnesium, 0.00004% of iron, 0.0004% of sodium, and 2.07% of potassium. Yebeyen *et al.* (2009) [27] also said that there were several minerals in gum arabic, namely calcium, magnesium, iron, sodium, phosphorus, potassium, and non detectable traces of Pb, Co, Cu, Zn, Ni, Cd, Cr, and Mn. So that the addition of gum arabic can increase the ash content of the fruit leather. The difference in ash content is possibly due to the different locations where gum arabic grows. The gum arabic used in this research is gum arabic that grows in Sudan, while the gum arabic used in [27] grows in Ethiopia. Thus it produced a different mineral content.

3.4 Crude Fiber Content

The crude fiber content of the Dewa starfruit-red guava fruit leather ranged from 1.78 to 2.32 percent. Table 1 showed that the crude fiber content of the fruit leather increased as the gum arabic concentration was higher. The ANOVA results showed that the addition of different concentrations of gum arabic did not have a significant effect ($p > 0.05$) on the crude fiber content of the fruit leather.

The increase in crude fiber content of fruit leather was due to the presence of soluble and insoluble dietary fiber in Arabic gum. In Arabic gum used, there are 76.20 mg of soluble dietary fiber and 13 mg of insoluble dietary fiber in 150 g of gum arabic, meaning that the concentration of gum arabic can increase fruit leather fiber content. This is in line with [28] that the addition of gum arabic can increase the amount of dietary fiber, because there was 78,099% of dietary fiber in gum arabic. The difference in fiber content is probably due to the different variants of gum arabic used. The gum arabic used in this study was a senegalese variant of gum arabic, while the gum arabic used in [28] was a kerensis variant of gum arabic. So that it produced different fiber content.

According to the Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2019, concerning the Recommended Nutritional Adequacy Rate (RDA) for the Indonesian people, the recommended amount of fiber per person per day ranges from 11-23 g for the age group of

infants and children, 22-37 g for the male 10-80 years old group, and 20-32 g for the 10-80 year old female age group. The crude fiber content of Dewa-red guava fruit leather ranges from 1.78% - 2.32%. So it can be said that 1 roll of fruit leather as much as 2 g can meet the nutritional adequacy rate of fiber of 0.2 - 0.5% for the category of infants and children, 0.14-0.23% for the male age group 10-80 years old, and 0.16-0.25% for the female age group 10-80 years old.

3.5 Vitamin C Content

The vitamin C content of Dewa starfruit-red guava fruit leather ranged from 76.91 to 86.53 mg / 100g. Table 1 showed that the vitamin C content of fruit leather increased as the gum arabic concentration was higher. The ANOVA results showed that the addition of gum arabic with different concentrations had a significant effect ($p < 0.05$) on the vitamin C content of the fruit leather. Gum arabic is a hydrocolloid that can form a gel so that it can protect vitamin C from oxidative damage [29]. Silalahi *et al.*, [30] also said that gum arabic also has the ability to inhibit the oxidation process. Therefore, the higher the concentration of gum arabic added, the higher the levels of vitamin C fruit leather.

According to the Regulation of the Minister of Health of the Republic of Indonesia, concerning the recommended nutritional adequacy rate (RDA) for the Indonesian people, the recommended amount of vitamin C per person per day ranges from 40 - 45 mg for the age group of infants and children, 50 - 90 mg for the male age group, and 50-75 mg for the female age group [31]. Vitamin C content of Dewa starfruit-red guava fruit leather ranged from 76.91 to 86.53 mg / 100 g. So it can be stated that 1 roll of fruit leather as much as 2 g can meet the nutritional adequate rate of vitamin C as much as 4% for the category of infants and children, 2-3% for the male age group 10-80 years old, and 2% for the female age group 10-80 years old.

3.6 pH Value

The pH value of the fruit leather ranged from 4.16 - 4.31. Table 1 showed that the pH value of the fruit leather increased with increasing concentration of gum arabic. The ANOVA results showed that the addition of different Arabic gum concentrations had a significant effect ($p < 0.05$) on the pH value of the fruit leather. Gum Arabic has the ability to bind water and water has properties to bind organic acids. So that the higher the concentration of gum arabic, the more water is bound, and organic acids are bound by water [32]. Therefore, the measured amount of free organic acid is less. A low acid concentration can be indicated by a high pH value.

The pH value of the fruit leather ranged from 4.16 to 4.31 which indicated that this fruit leather is an acid food. Acid food is defined as a food with a pH value of 4.60 or lower [33]. Lower pH in fruit leather would be advantageous because it would

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not be support growth of disease-causing bacteria. According to his research [34], gum arabic dissolves at acidic pH. Ref [35] states that gum arabic can reach a maximum viscosity at pH 3.9 - 4.9. This pH condition will help form the colloidal properties of the fruit leather solution, so that the fruit leather sheets can be formed properly.

The pH value of the fruit leather starfruit-red guava ranged from 4.16 - 4.31 which indicated that this fruit leather was an acidic food. Acidic foods are defined as foods that have a pH value of 4.60 or lower than 4.60 [33]. Low pH value in the fruit leather is a favorable condition, because this condition will not support the growth of disease-causing bacteria. According to Hutapea [34], gum arabic is soluble at acidic pH, while [35] stated that gum arabic can reach a maximum viscosity at pH 3.9 - 4.9. This pH condition will help to form the colloidal properties of the fruit leather solution, so that fruit leather sheets can be formed properly.

3.7 Water Activity Value

The water activity value of fruit leather ranged from 0.44 to 0.49. Table 1 showed that the water activity value of fruit leather relatively decreased with the increased in gum arabic concentration. The ANOVA results showed that the addition of different gum arabic concentrations did not have a significant effect ($p > 0.05$) of the water activity (aw) value of the fruit leather. Water activity is the amount of free water in food materials that can be used for the growth of microorganisms. The decrease in the value of water activity was associated with the decrease in water content, indicating the decrease amount of free water which required for microorganism activity. Water that evaporated during the drying process is included in the free water group which is not strongly bound [36].

Water activity can predict the types of microorganisms that can live and have the potential to become a source of decay and infection. The value of water activity on the fruit leather was lower than the aw value for the growth needs of bacteria, molds and yeasts. Pathogenic microorganisms could not grow at $aw < 0.86$, while molds and yeasts were more tolerant of these conditions. Wherein the mold and yeast did not grow at $aw < 0.62$ [37]. The relatively small value of water activity in fruit leather products can inhibit the growth of bacteria, mold, and yeast. However, the aw value of 0.44-0.49 in fruit leather still allowed to lipid oxidation, non-enzymatic browning, and enzyme activity.

3.8 Total Bacteria Value

The total bacteria value of fruit leather indicated that the bacterial growth less than 2.5 CFU / g. According to the Bacteriological Analytical Manual [16], the conditions for the plates that can be counted are 25 to 250 colonies. However, based on the results shown in Table 1, the resulting bacterial colonies were less than 25, so the data obtained could not be analyzed by ANOVA.

According to SNI 7388 : 2009 [38], the maximum standard limit for microbial contamination of dried fruit sweets for total bacteria is 1×10^5 colonies / g.

Based on the total results of the fruit leather bacteria, it can be stated that the total bacterial Dewa starfruit-red guava fruit leather still meets the standard of dried fruit sweets. The total value of bacteria obtained is relevant with the result of aw fruit leather value, which is less than 0.9, so that this condition can inhibit the growth of bacteria in the Dewa starfruit-red guava fruit leather product. Low water content and pH value can also inhibit microbial growth and extend shelf life, which further affected the health of consumers [39].

Based on this, gum arabic has an effect in reducing the pH of the Dewa starfruit-red guava fruit leather, so that low pH conditions can inhibit the growth of microorganisms. This was in line with the effect of gum arabic in reducing the water content of the fruit leather, which showed the decreasing amount of free water required for microorganism activity.

3.9 Total Yeast and Mold Value

The total yeast and mold value of fruit leather indicates the growth of yeast and mold less than 1.0 CFU/g. According to the Bacteriological Analytical Manual [17], the requirements for the plates that can be counted are 10 to 150 colonies. However, based on the results shown in Table 1, the resulting yeast and mold colonies were less than 10, so the data obtained could not be analyzed by ANOVA.

According to SNI 7388 : 2009 [38], the maximum standard limit for microbial contamination of dried fruit sweets for total yeast and mold were 5×10^1 colonied/g. Based on the results of the total yeast and mold, it can be stated that the total yeast and mold of Dewa starfruit-red guava fruit leather still met the standard of dried fruit sweets. The total value of yeast and mold obtained relevant with the aw value fruit leather that is produced, which is less than 0.6 will inhibit the growth of yeast and mold in the products of Dewa starfruit-red guava fruit leather. These results were expected since fruit leathers had low pH and low water content. Thus this fruit leather was expected to have a stable shelf-life for several months. Similar results of microbial stability of fruit leather are also reported in guava papaya fruit leather, the growth of microorganism were also well within the safe limit for consumption till 4 months of storage period [40].

Based on the research results, gum arabic has an effect in reducing the pH of the Dewa starfruit-red guava fruit leather, so that low pH conditions can inhibit the growth of microorganisms. This is in line with the effect of gum arabic in reducing the water content of the fruit leather, which shows the decreasing amount of free water required for microorganism activity.

3.10 Sensory Test

The sensory test of the Dewa starfruit-red guava fruit leather includes the hedonic test and the hedonic quality for the parameters of color, aroma, texture, and flavor. The results of the fruit leather sensory test are presented in Table 2.

3.10.1 Color

Color, an important attribute in food products, can be assessed either by a sensory panel [41]. The score value of color on fruit leather ranged from 3.0 to 3.5 (golden yellow - orange) with acceptance value ranged from 3.7 - 3.8 (like). The ANOVA results showed that the addition of gum arabic with different concentrations had a significant effect ($p < 0.05$) on the score value of color on the fruit leather.

Table 2 Sensory test of Dewa starfruit - red guava fruit leather

Concentration of gum arabic	Parameters	Attributes			
		Color	Starfruit Aroma	Starfruit Taste	Texture
0%	Score	3.0 ± 0.08 ^a	2.5 ± 0.08	3.5 ± 0.03	3.5 ± 0.08 ^a
	Acceptance	3.8 ± 0.06	3.6 ± 0.08	3.9 ± 0.03	3.6 ± 0.03 ^{ab}
0.5%	Score	3.1 ± 0.06 ^{ab}	2.7 ± 0.05	3.5 ± 0.08	3.6 ± 0.05 ^a
	Acceptance	3.8 ± 0.12	3.6 ± 0.10	3.9 ± 0.09	3.6 ± 0.05 ^b
1%	Score	3.3 ± 0.05 ^b	2.7 ± 0.16	3.5 ± 0.10	3.7 ± 0.03 ^b
	Acceptance	3.8 ± 0.06	3.6 ± 0.08	3.8 ± 0.03	3.8 ± 0.05 ^c
2%	Score	3.5 ± 0.05 ^c	2.7 ± 0.12	3.5 ± 0.03	2.6 ± 0.10 ^c
	Acceptance	3.8 ± 0.06	3.6 ± 0.12	3.9 ± 0.05	3.7 ± 0.03 ^c
2.5%	Score	3.5 ± 0.14 ^c	2.8 ± 0.36	3.5 ± 0.08	2.7 ± 0.08 ^c
	Acceptance	3.7 ± 0.06	3.6 ± 0.08	3.8 ± 0.03	3.5 ± 0.05 ^a

Score description:

Score : **Color** : 1 (light yellow) ; 2 (yellow) ; 3 (golden yellow) ; 4 (orange) ; 5 (red). **Starfruit Aroma** : 1 (not very strong) ; 2 (not strong) ; 3 (slightly strong) ; 4 (strong) ; 5 (very strong). **Starfruit Taste** : 1 (not very strong) ; 2 (not strong) ; 3 (slightly strong) ; 4 (strong) ; 5 (very strong). **Texture** : 1 (very inelastic) ; 2 (not elastic) ; 3 (slightly elastic) ; 4 (elastic) ; 5 (very elastic)

Acceptance : 1 (very dislike) ; 2 (dislike) ; 3 (rather like) ; 4 (like) ; 5 (very like)

The yellow color of the fruit leather indicated the presence of β -cryptoxanthin which is a color pigment in starfruit [42]. While the orange color in the fruit leather is the result of a combination of yellow pigments in star fruit and red pigments in red guava. According to [43], red guava has carotenoid compounds, especially lycopene pigments of 6900 $\mu\text{g}/100\text{ g}$ and β -carotene of 430 $\mu\text{g}/100\text{ g}$ [44]. According to [45], the dehydration process can change the surface characteristics of food, as well as its color and reflectance. Chemical changes in pigments such as carotene and chlorophyll are produced by heat and oxidation during drying. In general, the longer the processing time and the higher the temperature, the greater the loss of the pigment.

Fruit leather with a concentration of 0% gum arabic has a golden yellow color. In comparison, the color of fruit leather with a concentration of 2.5% gum arabic tends to be reddish yellow (orange), which means it was darker than the color of the fruit leather without the addition of gum arabic. This is supported by [11] which stated that the level of preference for panelists to the color of jackfruit fruit leather decline along with the higher concentration of gum arabic. The color change is caused by the Maillard reaction. The Maillard reactions in fruit leather is possibly caused by the presence of proteins contained in gum arabic. Apart from the protein content, gum arabic also contains monosaccharide molecules which act as reducing sugars [11].

3.10.2 Aroma

The value of the aroma quality assessed from the

Dewa starfruit-red guava fruit leather is the intensity of the starfruit aroma. Table 2 showed that the value of the fruit leather aroma ranged from 2.5 to 2.8 (rather strong), which indicated that the scent of starfruit from the fruit leather was rather strong, with an acceptance value, was 3.6 (like). The ANOVA result showed that the addition of gum arabic with different concentrations did not have significant effect ($\alpha = 0.05$) to the value of the score aroma of fruit leather.

According to [47], gum arabic is odorless when consumed by humans, so the addition of gum arabic did not affect the aroma of fruit leather. This is reinforced by [48], that hydrocolloids do not contain volatile ingredients which can cause aroma and color to food ingredients. The value of score aroma that is assessed from the Dewa starfruit-red guava fruit leather is the intensity of the starfruit aroma: According to [49], there were fifty-six volatile components in starfruit identified (8.9 mg/kg), the main ones being butyl acetate, ethyl decanoic and hexadecanoic acid.

3.10.3 Taste

The value of the taste quality assessed from the Dewa starfruit-red guava fruit leather is the intensity of the starfruit taste. Table 2 showed that the value of the fruit leather taste is 3.5 (strong) which indicated that the taste of starfruit from the fruit leather was strong, with an acceptance value ranged from 3.8 to 3.9 (likes). The ANOVA results showed that the addition of gum arabic with different concentrations did not have a significant effect ($p > 0.05$) to the value of the score taste of fruit leather. It caused of gum arabic has no taste,

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so the taste produced by the Dewa starfruit-red guava fruit leather is the original taste of starfruit. Similar results of their research that the addition of gum arabic did not affect the taste of the product [50].

3.10.4 Texture

The value of the score texture assessed from the Dewa starfruit-red guava fruit leather was the intensity of the fruit leather elasticity. Table 2 showed that the value of the fruit leather texture ranged from 2.6 (slightly elastic) to 3.5 (elastic), with a acceptance value ranged from 3.5 to 3.8 (like). The ANOVA results showed that the addition of gum arabic with different concentrations had significant effect ($p < 0.05$) to the value of the score texture of fruit leather.

Texture is an important parameter in determining the quality of the fruit leather. The texture produced by the fruit leather is influenced by the type and concentration of hydrocolloids [51] [52]. The texture parameter tested on the panelists is the level of elasticity of the fruit leather. The elasticity level of the fruit leather increased until the addition of 1% gum arabic, but decreased in the addition of 2% and 2.5% gum arabic. The decrease in the elasticity of the fruit leather possibly caused by the concentration of gum arabic that is too high.

In this research, gum arabic act as a gelling agent. Gel formation is a process of cross-linking polymer chains to form a continuous three-dimensional network capable of trapping liquids, forming a rigid and sturdy texture [19]. This made the fruit leather difficult to break because it required a large amount of energy to break these cross-links. Thus the higher concentration of gum arabic, then the more water was bound by gum arabic, so that the amount of free water contained in the material decreased, as a result the fruit leather water content was lower. This caused a decrease in the level of elasticity of the fruit leather [53].

The decrease in the level of elasticity of the fruit leather was also caused by the increase in the tensile strength value along with the increasing concentration of gum arabic. This is relevant with [54]. Rahmanto et al. [54] studied the jackfruit fruit leather, which showed that the increasing the concentration of gum arabic, the resulting decreased water content of the fruit leather, which caused the texture of fruit leather tight and less elastic. The addition of gum arabic with a 0.9 % w/w was too high and caused the texture of the fruit leather was tough, dry texture, and difficult to chew. This statement is directly proportional to the water content of the Dewa starfruit-red guava fruit leather relative decline with the concentration of gum arabic. Siburian and Dahang [55] also stated that high water content will produce a soft texture indicated by a lower texture value. Therefore, there is optimum limit to use a gum arabic to produce the desire texture of fruit leather.

4.0 CONCLUSION

1. The addition of gum arabic at different concentrations in produced a Dewa starfruit-red guava fruit leather was significantly different at $\alpha = 0.05$ on the parameters of tensile strength, water content, ash content, vitamin C content, pH value, hedonic quality value of color, hedonic value and hedonic quality value of texture. However, there is no significant effect on crude fiber content, water activity value, hedonic value of color, hedonic value and hedonic quality value of aroma, as well as hedonic value and quality hedonic value of flavor.
2. Fruit leather which produces the best quality is the fruit leather with the addition of 0.5% gum arabic with the parameters of the tensile strength value of 437.38 gf, water content of 7.38%, ash content of 2.02%, vitamin C content of 77.08 mg / 100 g, crude fiber content of 1.85, pH value of 4.22, water activity value of 0.48, total bacteria value of <2.5 CFU/g, total yeast and mold value of <1 CFU/g, with golden yellow color, slightly strong starfruit aroma, strong star fruit flavor, and elastic fruit leather texture. In addition, 1 roll of fruit leather as much as 2 grams can meet the nutritional adequacy rate of vitamin C by 4% for the infant and child category, 2-3% for the male age group 10-80 years, and 2% for the 10-80 years, and can meet the nutritional adequacy rate of fiber of 0.2 - 0.5% for the category of infants and children, 0.14-0.23% for the male age group 10-80 years, and 0.16-0.25% for the 10-80 year age group for women.

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