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Physical and Chemical Characterization of Manalagi Apple (*Malus sylvestris* Mill*)* Leather Enriched with Either Mango, Pineapple or Dragon Fruit

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Abstract
Manalagi apple leather has the potential to be an invention for new processed products made from fruit pulp andand undergo a drying process. The main problem is that apple leather has less plastic texture, non-variative color, taste, and stickiness. For this reason, in this study other fruits were added in specific proportions and food additives, such as maltodextrin, to improve the physicochemical and organoleptic characteristics of manalagi apple leathers. This study used the Split-split Plot Design method with three factors. The factor I is a type of fruit (red dragon fruit, pineapple, mango), factor II is the variation in proportion ((25:75)%, (50:50)%, (75:25)%), factor III is maltodextrin concentration (5%, 10%, 15%). The three best treatments for each type of fruit substitution were apple leather enriched with 50% dragon fruit and 10% maltodextrin; enriched with 75% pineapple and 10% maltodextrin, and enriched with 75% mango and 10% maltodextrin. The implications of this research are as follows: it provides valuable and additional information about the possibility of inferring that the hydrocolloids used, as well as the other raw materials, are a good foundation for making healthy fruit leather due to their nutritional and technological quality.
Keywords: Hardness; Tensile Strength; Elongation; Fruit Leather, Manalagi Apple, Maltodextrin

1. Introduction

Fresh fruit tends to be less preferred, and the consumption rate is relatively low. Fruit is an agricultural commodity that has the main role of meeting the nutritional adequacy of the community through its fiber, vitamins, and mineral content [1]. Therefore, processing fruits into dry processed foods can increase the selling value of fruit, provide healthy processed foods, and be a profitable business.

One of the processed dried fruit that is quite interesting is fruit leather. Fruit leather is made from fruit pulp by mixing sugar, citric acid, and other dried ingredients. This processed fruit has a plastic texture, can be rolled up, and has a shiny appearance like skin with a distinctive fruity aroma and taste [2, 3]. The main problems in producing fruit leather are the less plastic texture, the color and taste not varied, and stickiness. For this reason, in this study, the addition of high-fiber substitution fruit is expected to improve the texture, color, and taste of fruit leather apples. Fiber functions as a gelling agent through its ability to form a gel matrix with water and increase the viscosity so that the final texture is more plastic [4].

Stickiness is also a significant obstacle in manufacturing fruit leather and plasticity. Sugar and pectin play a role in increasing the surface adhesion force so that fruit leather tends to stick to the packaging and fingers when consumed. Hydrocolloids such as maltodextrin, pectin, and tragacanth have essential functional properties in the food and pharmaceutical fields [5, 6]. Therefore, in this study, maltodextrin was added to effectively reduce fruit leather's stickiness by decreasing the adhesion force [7]. Maltodextrin also has the ability to be a fat bulker, prevent crystallization and browning, and form a film [8]. The combination of maltodextrin and gum arabic also functions as an encapsulator that protects essential compounds from heat and oxidation [9]. It is necessary to understand the properties of texture profiles, such as hardness and tensile strength in order to physically define hygroscopic solid foods like fruit leathers. Hardness analysis is a parameter used to determine the level of hardness of a material or product. The hardness value states the amount of force required until the product undergoes a change in shape (deformation). A material or product is hard if the force required to achieve deformation is very high. This is because of the correlation between hardness and how easily fruit leather may be eaten. The more power it takes to bite and consume a slice of fruit leather, the harder it is, which has a negative impact on customer acceptability. This research's primary goal is to investigate how the addition of maltodextrin affects the physical dan chemical properties of fruit leathers manufactured from apples mixed with dragon fruit, pineapple, or mango puree and evaluate how their mechanical and sensory characteristics change with water activity.

2. Method

Materials

Materials for the manufacture of fruit leather: manalagi apples obtained from the Bumiaji Batu apple plantation; manalagi mango, red dragon fruit, sugar, and butter obtained from Pasar Gadang; maltodextrin and citric acid obtained from CV Sari Kimia Raya; Arabic gum obtained from CV Nurra Gemilang; as well as drinking water. Materials for chemical analysis consisted of distilled water, 0.25N H_2SO_4, 0.3 N NaOH, 10% K_2SO_4, 95% alcohol, litmus paper, and coarse filter paper for crude fiber content analysis; 1% starch solution, 0.01 N iodine standard solution, and fine filter paper for analysis of vitamin C levels.

Equipment

The equipment for making fruit leather includes measuring cups, thermometers, digital scales, ovens, blenders, stoves, steaming pans, baking sheets, baking paper, plastic gloves, basin, and stirrer. Tools for physical and chemical analysis include color reader, digital force gauge, tensile strength, desiccator, analytical balance, furnace, oven, the crucible, thermometer, cup clamp, crushing mortar, electric stove, glassware, reflux, glass stirrer, measuring pipette, dropper, and bulb.

Research Design

Three treatment factors were included in this study's split-split plot design, including the type of substitution fruit (red dragon fruit, pineapple, mango), proportion variation ((25:75) %, (50: 50)%, (75:25)%), and maltodextrin concentrations (5%, 10%, 15%). Each treatment was repeated three times so that 27 combinations and 81 experimental units were obtained. The data obtained were analyzed using the Analysis of Variance (ANOVA) method to determine whether each treatment had a significant effect. If there is a significant or significant effect on the three treatments, it will be continued with the 5% LSD (Least Significance Different) test and 5% DMRT test (Duncan Multiple Range Test). The organoleptic test was carried out using Hedonic Scale Scoring.

Fruit Leather Preparation

Apples were sorted, removed the stalks, washed with running water, and steam blanched at 90°C for 3 minutes. The apples are then cut into small cubes and added 30% water before being mashed with a blender. Red dragon fruit, pineapple, and mango were peeled, and only the flesh was taken. For pineapples, the eye of the fruit was also separated from the fruit's flesh. Each substitution fruit was mashed with a blender to obtain a puree.

Apple pulp and puree (dragon fruit, pineapple, or mango) are mixed in various proportions (25:75) %, (50:50)%, and (75:25)% in a saucepan and added gum Arabic 1%, maltodextrin (5%; 10%; and 15%), sugar 30%. Mixing was carried out while stirring and heated (±120-140° C). When the mixture boils, reduce the heat (±65-75° C), add butter, and stir until all the butter is melted. Turn off the heat when the butter has melted, and 0.2% citric acid is added. The dough was stirred until evenly distributed and poured onto a baking sheet that was lined with paper with a thickness of ± 3mm. The dough of fruit leather was dried in a cabinet dryer at 55-60°C for 5 hours to obtain apple fruit leather.

Analysis

Analysis of this study includes colour analysis using colour reader to record the values of L, a*, and b* [10], tensile strength [11], elongation [11], and hardness [11], chemical analysis (moisture content [12], ash content using standard dry ashing method from AOAC [13], crude fiber content using standard gravimetry method from AOAC [14], and vitamin C levels using standard iodometry method from AOAC [13]) as well as organoleptic assays.

3. Results And Discussion

3.1 Characteristics of Raw Materials

This study used 4 (four) types of fruit as raw materials in manufacturing fruit leather apples: manalagi apple, red dragon fruit, queen, and manalagi mango. Raw material analysis was carried out for these four types of fruit to determine the initial condition of the material before being processed into fruit leather and the difference after being processed into fruit leather in various concentrations.

Tabel 1 Characteristics of Raw Material

Parameters	Manalagi Apple		Red Dragon Fruit		Pineapple		Mango	
	Analysis	Literature [15]	Analysis	Literature [16]	Analysis	Literature [17] [18]	Content	Literature [19] [18]
Moisture (%)	84.65 ± 0.77	84.05	88.73 ± 0.90	90[b]	86.20 ± 0.48	86.00	85.95 ± 2.21	83.46
Ash (%)	0.28 ± 0.07	0.30	0.29 ± 0.02	0.28[b]	0.30 ± 0.02	0.22	0.25 ± 0.34	0.36
Crude Fiber (%)	1.38 ± 0.14	1.25	0.85 ± 0.12	0.700-0.900[b]	2.03 ± 0.97	2.40	2.55 ± 0.39	2.37
Vitamin C (mg/100gr)	5.00 ± 0.20	7.43	8.34 ± 0.81	8.00- 9.00[b]	33.70 ± 3.93	47.80	21.40 ± 3.20	36.40
Color								
(L)	43.97		27.50		67.55		59.16	
(a)	5.18		44.03		6.27		10.75	
(b)	18.10		4.17		58.14		44.10	

Note: *Each analysis result is the average of 3 replications

3.2 Physical Analysis Fruit Leather

3.2.1 Hardness

A parameter used to assess the degree of hardness of a material or product is the hardness analysis. The hardness rating indicates how much force must be applied before the product changes shape (deformation).

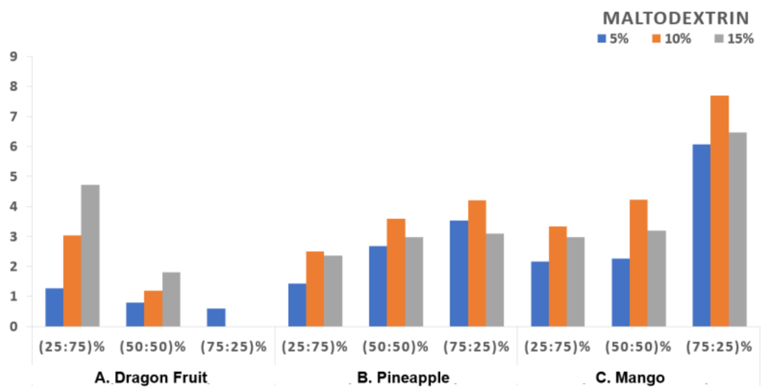

Fig. 1 The hardness of manalagi apple fruit leather

Based on the DMRT and LSD 5% test, the substitution of red dragon fruit, pineapple, and mango was significantly different from fruit leather hardness. Pineapple and mango have higher hardness values which are based on naturally different fruit characteristics. Pineapple and mango fiber content is higher than red dragon fruit. Fiber plays a role in the formation of fruit leather. Fibers, especially pectin, function as a balance between sugar and water bonds in a gel matrix that can also bind to water [20].

The more gel matrix formed, the higher the viscosity and body fruit leather. As a result, the product's texture becomes more compact, not easily brittle, and hard.

Maltodextrin is able to form a body and increase viscosity through its hygroscopic nature [8]. Therefore, the hardness of the addition fruit leather with 10% maltodextrin is higher than fruit leather with 5% maltodextrin. However, the hardness of the fruit leather of manalagi apples actually decreased when maltodextrin was added at a concentration of 15%. The higher the maltodextrin added, the higher the water bound to the fruit leather. The high water content will increase the viscosity but decrease the strength of the gel formed. This causes the gel in the fruit leather to be weak and easily deformed, which causes the hardness of the fruit leather to decrease.

3.2.2 Tensile Strength and Elongation Test

Elongation is the percentage increase in the maximum length of a product to the initial length. The mechanism for calculating elongation is to apply a tensile force to the fruit leather until it breaks. Elongation is closely related to tensile strength or tensile strength. Elongation is expressed as a quantitative representation of the fruit leather's ability to stretch [21].

The average tensile strength and elongation fruit leather, moreover the substitution of pineapple and mango substitution is higher with the value of the two not much different. Tensile strength and elongation are closely related to plasticity and gel formation in fruit leather. During the heating process, the formation of a three-dimensional mesh matrix by fiber and sugar produces fruit leather that is stiff, tough, and resistant to pressure [22]. Therefore, the higher the fiber, the fruit leather becomes more compact and requires more force when stretched. However, stretching can be done more maximally to increase the elongation value obtained. The fiber in pineapple and mango is higher than that of dragon fruit, so the tensile strength and elongation of the fruit leather of dragon fruit substitution are the smallest.

Tabel 1. Tensile strength and elongation apple leather

Replication	Tensile Strength			Elongation		
	Dragon fruit	**Pineapple**	**Mango**	**Dragon fruit**	**Pineapple**	**Mango**
1	1.2	4.0	3.5	20.00	40.00	30.00
2	1.0	3.9	3.4	13.33	36, 67	23.33
3	1.1	3.8	3.6	16.67	33.33	26.67
Average	1.1	3.9	3.5	16.67	36.67	26.67

The tensile strength value in this study is quite low when compared to several previous research on red dragon fruit and mango fruit leather, the tensile strength values obtained ranged from 6.4 to 9.77 N [21], the drying time used was longer, 6-8 hours. The longer drying time causes the fruit leather texture to be drier and the sugar crystallization to increase. As a result, the texture is more plastic and the tensile strength is higher. In other research on the manufacture of anna apple fruit leather [21], the tensile strength values were obtained between 5.50 to 12.52. The higher value can be caused by the use of wheat flour as a filler. The two previous studies that have been described also did not add water or other solvents, so the viscosity was higher. The water in the material will diffuse into the gel to soften the formed gel, which results in a decrease in the tensile strength value. Manalagi apple fruit leather in this study did not use fillers; the drying time was relatively short, 5 hours, using drinking water in the apple crushing process, and using hydrocolloid gum Arabic so that the tensile strength value was lower.

The elongation value obtained in this study is quite large compared to other studies. The research [21] has an elongation value of 4.2% - 9.11% of the dragon fruit peel and gadung mango fruit leather samples. In this study, 1.5% pectin was used as a binder with a drying time of 6, 7, and 8 hours. Long drying time results in a product with a lower moisture content and a harder texture. As a result, the product's elasticity decreases and the elongation percentage is smaller. While in [21] the percentage of elongation is 8.61% - 12.78% from the Anna apple fruit leather sample. In this study, carrageenan was used as a binder and wheat flour as a filler in various concentrations.

Various factors determine elongation and elasticity, including water content, sugar concentration, acid, plasticizers, pectin (fiber), and others. In manufacturing fruit leather, manalagi apples do not add plasticizers such as glycerol or sorbitol. However, the combination of gum arabic and maltodextrin is able to retain some of the water from the drying process so that the product is not hard and can stretch optimally.

3.3.3 Color Analysis

CIELab is a method of physical color analysis introduced by CIE (*Commission internationale de l'eclairage*) in 1976. This method consists of 3 main parts, namely L* (*lightness*), a* (red and green), and b* (yellow and blue).

3.3.3.1 Brightness (L)

The lightness (L) of a product indicates its brightness level. The capacity of light to permeate a substance is defined as brightness. In CIELab, L values range from 0 to 100, with 0 representing very black and 100 representing a white dot representing very bright [23].

The higher the substitution fruit compared to the manalagi apple fruit leather, the brighter the apples contain the enzyme polyphenol oxidase, which is active when the fruit is peeled or crushed. This enzyme reacts with oxygen to produce O-quinone which serves as natural protection against bacteria and fungi. O-quinone will undergo further reaction to form a brown-black pigment [24]. The increase in maltodextrin used caused the fruit leather of manalagi apples to be brighter. The presence of maltodextrin can protect essential compounds such as pigments, flavonoids, and enzymes from damage caused by the heat process. This is in line with [8] where maltodextrin has several functional properties such as forming a film or thin layer, inhibiting browning, emulsifier, and functioning as an encapsulating compound.

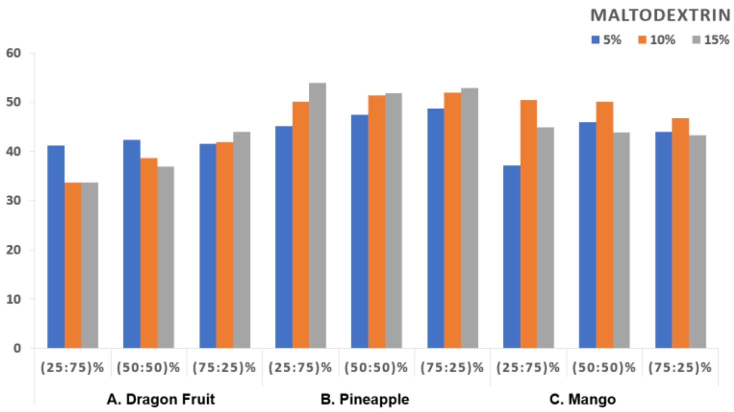

Fig. 2 The brightness value of manalagi apple fruit leather

3.3.3.2 Redness (a*)

The a* value in CIELab using a color reader indicates the degree of redness-greenness of the product. The range of a* values is in the number -80 to 100. The number notation 0-100 indicates that the product is reddish in color. Meanwhile, 0 to -80 means that the resulting product tends to be green [23].

The more proportion of substituted fruit compared to manalagi apple increased the reddish value (a*) fruit leather, except for the substitution of pineapple. Red dragon fruit flesh is naturally red-purple due to betacyanin pigment [25]. In contrast, pineapples and mangoes are naturally bright yellow to orange-yellow. The reddish value (a*) fruit leather for mango substitution is slightly higher than for pineapple. This can happen because the mango flesh is more yellow-orange, where the orange color tends to be close to the red color. The reddish value of fruit leather was higher as the maltodextrin concentration increased. Maltodextrin, an encapsulated compound, can protect the pigments in fruit, especially red dragon fruit, from heat damage.

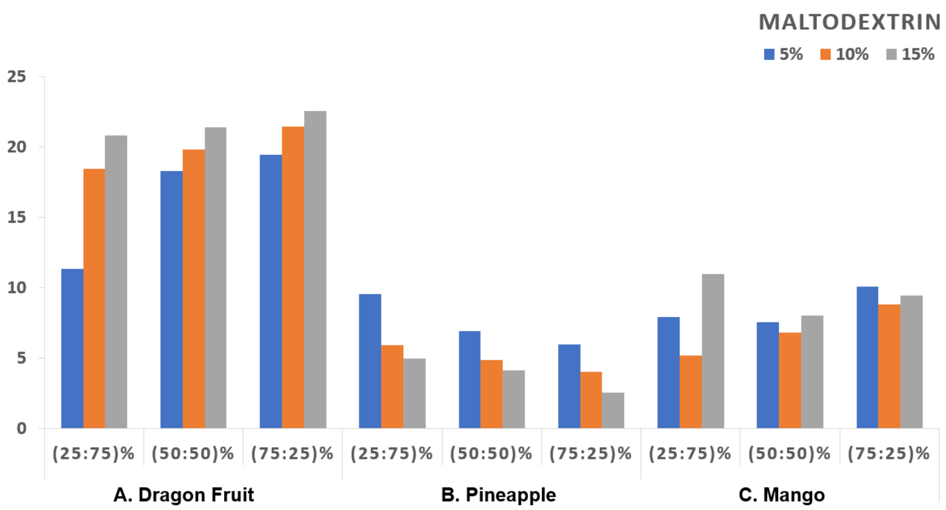

Fig. 3 The redness value of manalagi apple fruit leather

3.3.3.3 Yellowness (b*)

The b* value in the CIELab method shows the yellowish-to-bluish value in the product. The value of b* is in the range of -70 to 70 where the plus (+) notation indicates the product tends to be yellow. On the other hand, the minus (-) notation means that the product being analyzed tends to be blue [23].

The more proportion of substituted fruit compared to manalagi apples resulted in a decrease in the yellowness value (b*) fruit leather, except for the substitution of pineapple. Pineapple is naturally yellow, which comes from the pigment carotene and xanthophyll. Maltodextrin is able to defend the pineapple pigment from damage. However, the b* value decreased when 15% maltodextrin was added in mango substitution. This is caused by a non-enzymatic browning reaction, namely the Maillard so that fruit leather gets darker and the yellow-orange color typical of mangoes fades. In dragon fruit substitution, adding maltodextrin reduces the value of b* (yellowness). Maltodextrin, an encapsulated compound, can protect the betacyanin pigment of red dragon fruit from heat damage [8].

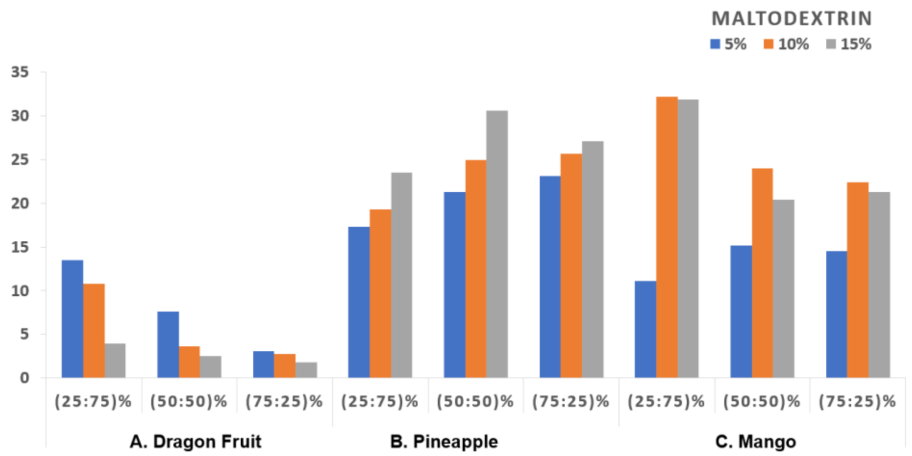

Fig. 4 Yellowness value of manalagi apple fruit leather

3.4 Chemical Analysis of Fruit Leather

3.4.1 Moisture Content

The quantity of water mass in a substance is indicated by its moisture content [26]. The water content of a food product is very crucial in determining the physical characteristics of the product and its shelf life [27]. The higher water content, especially in dry-based products, indicates that the product quality is not good and is easily damaged. The water content of good fruit leather is 10-20% [2].

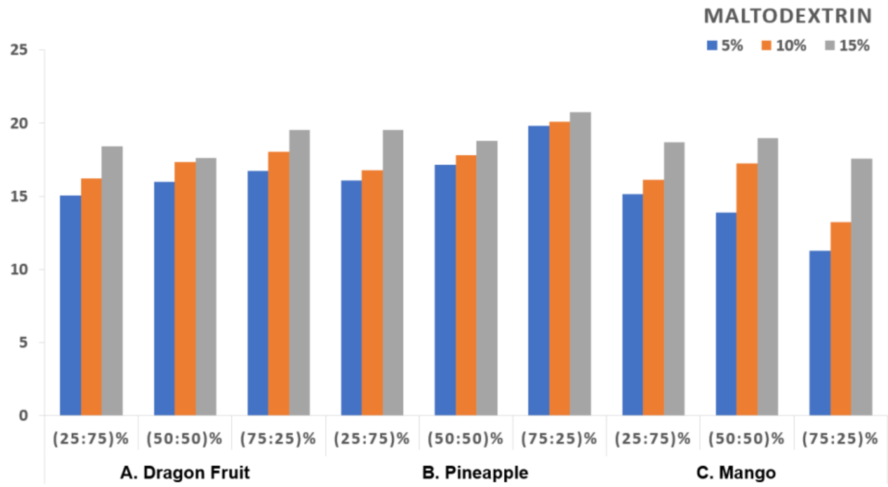

Fig. 5 Moisture content (%) of manalagi apple fruit leather

The increase in water content occurred along with the addition of maltodextrin concentration. Maltodextrin has functional properties as a good filler, thickener, body shaper, and water binder [8]. The higher the use of maltodextrin, the more free water is bound, so the water does not evaporate during the drying process. This statement is in accordance with [26] wherein the hygroscopic nature (ability to absorb water) of maltodextrin comes from the hydroxyl group that can bind water from the environment. So, the amount of maltodextrin concentration is directly proportional to the level of water vapor reabsorption.

3.4.2 Ash Content

Ash in food refers to the inorganic residue that remains after either ignition or oxidation of organic matter. What is meant by inorganic residues comes mainly from mineral compounds [28]. The ash content in foodstuffs generally has a maximum limit based on applicable regulations. This is because the high ash content can be caused by other things such as poor product processing or heavy metal content.

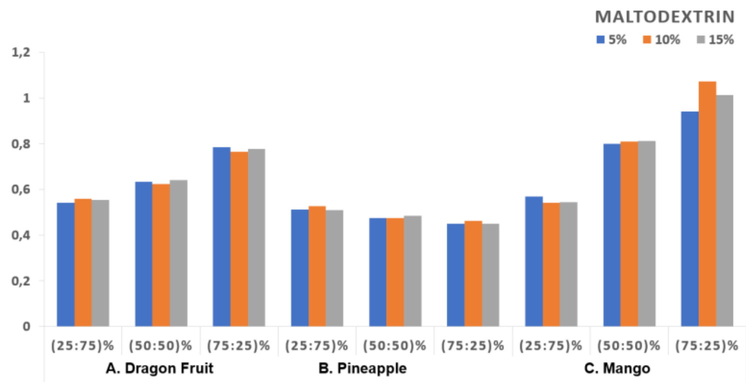

Fig. 6 Ash content (%) of manalagi apple fruit leather

Based on Analysis of Variance (ANOVA), the factors of substitution fruit type, proportion variation, and their interaction have a p-value <0.05, which means that there is an influence and interaction between the two factors. While the maltodextrin factor and the interaction between factors involving maltodextrin has a p-value > 0.05, which means that there is no significant effect on the resulting ash content. Maltodextrin is derived from starch derivatives and is low in inorganic content, so it does not contribute to ash when added to food [29].

3.4.3 Crude Fiber

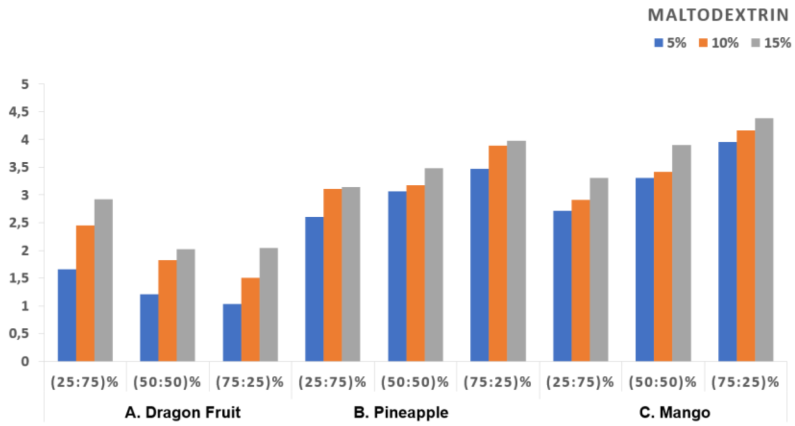

Fig. 7 Crude fiber content of manalagi apple fruit leather

Fiber is divided into 2: crude fiber and dietary fiber. Total crude fiber is always smaller when compared to dietary fiber. Because in the crude fiber analysis process, there is a loss of fiber as much as 80% for hemicellulose, 50-90% for lignin, and 20-50% for cellulose, while in food fiber analysis there is no loss [30].

Crude fiber content of leather, especially fruit variations dragon fruit, decreases as the proportion of red dragon fruit increases. The crude fiber of red dragon fruit flesh is only 0.7-0.9% [16]. While the value of crude fiber is higher along with the increase in the proportion of pineapple and mango. This can happen because, basically, the crude fiber value of pineapples and mangoes is higher than apples. The increase in maltodextrin concentration also causes the crude fiber content to increase. However, the increase was not significant because naturally, the crude fiber in maltodextrin was only about 0.5 - 1% [29].

3.4.5 Vitamin C

Vitamin C is easily soluble in water and easily oxidized. The oxidation process of vitamin C is faster when exposed to thermal treatment, sunlight, alkali, enzymes, oxidizing agents, and copper and iron catalysts [31]. Although the temperature is not too high (< 100 ° C), vitamin C, naturally present in fruits, is at risk of being damaged. For this reason, maltodextrin was added to fruit leather as an encapsulated compound expected to maintain the presence of vitamin C.

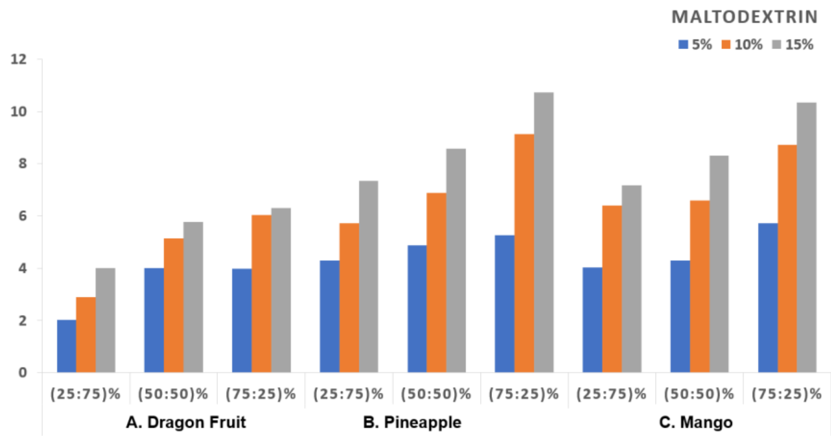

Fig. 8 Vitamin C of manalagi apple fruit leather

The levels of vitamin C in manalagi apples are naturally low compared to the three types of companion fruit. Increasing the concentration of maltodextrin also causes the value of vitamin C obtained to be higher. Maltodextrin is a commonly used material in encapsulation to protect essential compounds from damage. The advantages of maltodextrin as an encapsulated material are that it has low viscosity, high solubility, and is an emulsifier. Thus, maltodextrin easily binds to essential compounds and forms a microencapsulated matrix [32].

The level of vitamin C obtained in this study is still relatively low compared to several previous studies. Fruit leather from dragon fruit skin and mango fruit (90%: 10%) contain vitamin C of 9.97 mg/100gram [33]. In [34], which makes pineapple fruit leather, the highest vitamin C content is obtained, up to 15.51 mg/100 grams. This may be due to the high water content in the final fruit leather of manalagi apples. While in these studies, the water content of fruit leather is <15%. The high water content indicates that the attraction between colloidal particles in the structure is still lacking, and there is enough space for free oxygen to cause the oxidation of vitamin C [34]. The high water content in this study was also related to the drying time, which only lasted 5 hours.

3.5 The Best Treatment

Sensory analysis in this study was conducted to test the level of acceptance and consumer preference and to determine the best three treatments from 27 samples. For this reason, the sensory test was carried out by the affective method using a hedonic scale of 1-7. The panelists used in this study were 60 people for primary data. Fruit leather apple manalagi is used as a product development, so the main focus of this research is to determine the level of acceptance and consumer preferences. The best treatment was determined by the optimal mean and was taken from each type of fruit, namely the sample for dragon fruit was 50% dragon fruit: 50% apple with 10% maltodextrin, the sample for pineapple was 75% pineapple: 25% apple with maltodextrin 10%, and the sample for mango fruit is 75% mango: 25% apple with the addition of 10% maltodextrin.

The addition of 10% maltodextrin is the most preferred, probably because maltodextrin as a coating material can retain volatile that bring the fruit's distinctive taste from the heat process. This is in line with [21], where maltodextrin as an encapsulate is able to form a body and bond to protect sensitive components such as antioxidants, flavors, vitamins, colors, and other nutritional elements. At a concentration of 15% maltodextrin, it is less favorable, probably due to the taste of the sample being too sweet and the emergence of aftertaste.

4. Conclusion

Pineapple and mango have higher hardness values which are based on naturally different fruit characteristics. Pineapple and mango fiber content is higher than red dragon fruit. Fiber plays a role in the formation of fruit leather. The best treatment was taken from each type of fruit substitution, so there were 3 the best treatments: apple leather enriched with 50% dragon fruit and 10% maltodextrin; enriched with 75% pineapple and 10% maltodextrin, and enriched with 75% mango and 10% maltodextrin. Maltodextrin was able to improve the physical characteristics of the leather fruit. There is an increasing need for healthful and convenient foods. Consumers are becoming more choosy and respect food's nutritional properties. This publication describes a study that was undertaken to investigate the effects of varying concentrations of maltodextrin on the manufacture of mixed leather from apple, dragon fruit, pineapple, and mango, as well as its physicochemical, chemical, and physical qualities. The implications of this research are as follows: it provides valuable and additional information about the possibility of inferring that the hydrocolloids used, as well as the other raw materials, are a good foundation for making healthy fruit leather due to their nutritional and technological quality.

Acknowledgments

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