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Storage Stability of Additive-free *Salacca sp.* Fruit Leather

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Abstract. We developed additive-free fruit leather made from snake fruit (*Salacca sp.*), one of the exotic fruits of Madura, Indonesia. Mature snake fruit variety native of Bangkalan Regency was peeled, the seed was discarded, and flesh was blanched for 5 minutes, cooled and then crushed in an electric blender to form a smooth slurry. The slurry was then cooked until thick, spread onto a flat surface, and then dried in an oven at 60°C until dry. Fruit leather with a water content of around 10% was kept in aluminium foil or polypropylene plastic bag at 25 and 35°C for 3 weeks. Every week, fruit leather was examined for tensile strength, water activity, colour (L, a b*values), and titratable acidity. Sensory analysis was performed using ten semi-trained panellists to score hardness, chewiness, sweetness, astringency, aroma, shininess, and cohesiveness. Results indicated that tensile strength apparently increased during storage. Polypropylene bag showed lower water activity and value, but higher titratable acidity of fruit leather. Storage time increased water activity, titratable acidity, but reduced all colour parameters. Higher storage temperature led to higher L and b values. On the contrary, sensory analysis results indicated the limited effect of factors studied. The shininess of fruit leather reduced with the progress of storage, and cohesiveness increased in the first week of storage only, followed by constant reduce towards the storage time. Astringency in snake fruit is a limiting factor. However, snake fruit leather showed moderate level (4.6 out of 9 score) of astringency.

Keywords: fruit leather, packaging, *Salacca* sp., storage, temperature

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1. Introduction

Consumption of processed fruit constantly exceeds that of fresh counterpart since ’70s [1]. Fruit leather or fruit roll-up has been recommended by FAO as an effective and simple way of preserving fruit. Fruit leather is also considered to fit recent consumers’ demand of ‘eat on-the-go’ style and healthy food consumption [2], that has a great market opportunity with wellness and indulgence being the main market drivers [3]. Fruit leather was also considered as ‘natural’ and functional food, where a middle-class group of consumers even had only a little concern with its probable high price [4]. Mango, pineapple, banana, and strawberry are some fruits commonly made into fruit leather due to their desirable characteristics for making fruit leather.

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Some types of fruit can be made into fruit leather without any pre-treatment nor food additive, such as jackfruit, guava, kiwifruit, mango, longan, apple [5]. Otherwise, the texturing agent is needed, including sugar, glucose syrup, pectin, gelatin, milk powder, organic acid, soy protein, soy lecithin, starch, wheat flour, soy flour, and maltodextrin [5]. Additive-free fruit leather can also be achieved by blending some fruits to improve texture and other quality, such as a mix of apple and apricot, and papaya and guava [5]. Pectin is commonly added up to 4%, and it positively relates to fruit leather moisture level, water activity, and negatively relates to puncture test [6]. Soy flour added to peach puree reduces sensory evaluation, although delays biochemical changes during storage [7]. Fruit leather is expected to stand storage up to 90 days [5], although some changes may have started by 30 days in the storage [6]. Snake fruit (Salacca zalacca) is one of the exotic fruits native of Indonesia and adjacent countries such as Thailand [8] and Malaysia [9]. The fruit is considered as an important source of antioxidant [8] [9] [10], which did not show a considerable difference in their antioxidant activities across varieties [10],. There are 30 types of snake fruit in Indonesia, having sweet to sour and bitter/astringent taste, soft to hard texture, creamy white to red colour, 1-2 to 2-3 seeds [11]. Although there is a broad range of snake fruit phenotype, it shows high genetic similarity [12]. Snake fruit was reported to contain high antioxidants [8] [9] such as polyphenol (8.46 mgGAE), anthocyanin (9.74 mgGCE), tannin (6.48 mgCE), and vitamin C (13.28 mgAA) [8], and antioxidant activities of 82.67% [9]. Consumption of snake fruit reduced low-density lipoprotein and increased antioxidant activities (2.2-azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) or ABTS, and 1,1-diphenyl-2-picrylhydrazyl or DPPH) of plasma lipid of control positive rat fed with basal diet and cholesterol [8].

No added preservative fruit leather had a big challenge in maintaining its quality during storage. Therefore, water activity, packaging, and storage temperature are important factors in determining its shelf-life. As far as we are concerned, there was not any work on fruit lather made solely from snake-fruit without any additive including a preservative. Hereby, we studied the physicochemical and sensory properties, as well as storage stability of snake-fruit leather packed in different temperatures and packaging material.

2. Materials and Methods

2.1. Materials

The local variety of fresh snake fruit (*Salacca sp.*) was obtained from a local market in Bangkalan, East Java, Indonesia. All other chemical reagents used for analysis were of analytical grade.

2.2. Preparation of Fruit Leather

Mature snake fruit was peeled, and the seed was discarded. The flesh was submerged in sodium metabisulphite solution (200 ppm) for 3 h and then washed thoroughly to remove the excess of sodium metabisulphite, then drained. The fruit flesh was pureed using a Waring blender, at high speed for 5 minutes. The puree was then cooked until thick, spread onto a flat surface, and oven-dried at 30 °C for 6-8 h to reach a moisture content of 5 %. The dried fruit leather was cut (5 cm × 10 cm) and stored in the pocket bag at room temperature for further analysis.

2.3. Experimental Design

Studies on the effect of storage temperature and packaging material was conducted in a factorial design with two factors, which were packaging material (polypropylene and laminated aluminium foil), and storage temperature (25 and 35°C). The studies on the effect of storage time (0, 1, 2, 3 weeks) was arranged as comparison of means. Experiment was run in duplicate. The confidence level was set at 95%.

3. Results and Discussion

3.1. Physical Properties

Hunter colour parameters (L, a, b) were affected by storage time (Table 1 and 2). Brightness of product, depicted by L value, was affected by all parameters and their interaction except type of packaging (Table 1). L value decreased significantly ($P<0.05$) towards the end of storage time, changed from 30.96 to 26.84 (Table 2). Value of a was affected by storage time and type of packaging (Table 1), but b value was only affected by storage time (Table 1). As storage time progressed, redness of product became more apparent, indicated by increased of a value from 15.61 to 16.63 (Table 2). Considerable decrease in a value was also reported in blueberry fruit leather, and gave red purple colour of the product during storage [13]. Decrease in yellowness was more pronounced in fruit leather packed in polypropylene pocket than that in laminated aluminium foil pocket. This result confirmed previous study that aluminium pocket better protect fruit leather product [19]. Similarly, creamy colour of snake fruit leather turned toward less yellowish by increasing storage time, as shown by reduce in b value from 51.50 to 44.93 (Table 2). Our result confirmed previous reports where browning index of fruit leather increased significantly after as soon as 2 weeks [17], or 4 weeks [14] storage at room temperature. Brightness of our product (30.96) was lower than that of mango leather made with soy and milk protein (42.50) [15].

Tensile strength is an important quality of fruit leather. In our work, this characteristics changed from 0.22 to 0.40 MPa during 3 weeks storage (Figure 1). Tensile strength of snake-fruit leather had lower tensile strength (0.22 to 0.4 MPa) compared to that of berry fruit leather (9 to 25 MPa) [16], but comparable to that of mango fruit leather [15]. Tensile strength likely negatively related to pectin concentration, but positively related to moisture content of fruit leather [16]. The lower tensile strength, the less energy to break fruit leather, which indicates more flexible and desirable texture [15].

Table 1. Statistical Significance of Treatments on Physical and Chemical Properties of Snake-Fruit Leather

Parameters	Storage time	Type of packaging	Storage temperature
L	0.000	0.937	0.000
a	0.003	0.001	0.444
b	0.000	0.096	0.001
Tensile Strength	0.000	0.870	0.526
Aw	0.000	0.000	0.460
Titratable Acidity	0.000	0.030	0.090

Note: not significant was $P \geq 0.05$), significant was $P < 0.05$

Table 2. Colour Profiles (L, a, b) of Snake-Fruit Leather as a Result of Different Storage Times

Parameters	Storage Time (Week)			
	0	**1**	**2**	**3**
L	30.96d	28.47 c	27.62 b	26.84 a
a	15.61a	16.87 ab	16.06 b	16.63 b
b	51.50a	48.20bc	46.54a	44.93b

Similar superscripts following values in the same row indicate significant difference at $P < 0.05$

3.2. Water activity

Water activity of snake-fruit leather was affected by storage time, type of packaging, and their interaction (Table 1). Water activity was increased from 0.64 to 0.69 by the end of storage, as expected. Water activity of our product was comparable to that of apple leather [14] [17], but higher than that of blue-berry [13] or apple-blackcurrant leather [16]. Higher Aw at 0.7 was reported to induce browning [14], which may explain reduce in brightness and less creamy appearance of our product during storage. As water activity can be an indicator for susceptibility of food for microbial growth, this snake-leather was prone to spoilage by osmophilic yeast which is known to deteriorate dried fruit where its water activity was 0.60 [18], and also the fruit leather was susceptible to growth of xerophilic fungi at water activity of 0.65 [18]. This relatively high water activity limits snake-fruit leather storage stability. Water activity was better maintained when fruit leather was kept in aluminium pouch, further confirm previous result [19].

3.3. Titratable acidity

Titratable acidity is an indicator for biological reaction taking place in food stuff. In our fruit leather, titratable acidity was increasing from 0.85 to 0.92 % at the end of 3 weeks storage. It is was not clear whether this change in titratable acidity was due to biochemical reaction or microbial growth, since microbial examination was not carried out in this work. Enzymatic reaction is still occurring in fruit with water activity as low as 0.60, and by water activity of 0.65

the reaction starts to increase rapidly. Therefore, there was a possibility that biochemical changes were more pronounced than microbial deterioration in determining titratable acidity of the fruit leather in our study. The absorbed moisture by fruit leather during storage was reported earlier [7], and this facilitated biological reaction which was expressed in several indicators such as increase in total soluble solid [7], and acidity [6] [7], vitamin C concentration and decline in pH [6], noticeable since the first week of storage. The biochemical changes was also reflected in the colour of fruit leather. Citric acid commonly found in fruit was suggested to cause darkening of fruit leather [20]. As the acidity of snake-fruit leather showed an increase in the storage, the darkening seemed to follow. Titratable acidity was also better retained when fruit leather was kept in laminated aluminium pouch, as oxygen and water vapour can be prevented from coming into the pouch and facilitates biochemical reaction within the product [19]. The increase in acidity can be an indicator for microbial growth in fruit leather [6].

In our work, storage temperature applied (25 and 35°C) did not show any substantial effect on product characteristics. Our finding was in contrast to previous study where storage temperature at 20°C prevented browning of apple fruit leather as compared to that kept in 30°C [14]. This difference towards storage temperature effect may be due to the nature of fruit used in the making of fruit leather, since apple is very prone to browning.

3.4. Sensory Analysis

Storage time was the only factor significantly ($P<0.05$) affecting sensory properties i.e. shininess and cohesiveness (Table 3). Interaction of storage time and storage temperature affected ($P<0.05$) shininess of fruit leather. The product was perceived by panellists to become less shiny (from 4.23 to 2.98) and less cohesive (5.23 to 4.45) towards the end of storage period. During storage, score for hardness and elasticity reduced, while those for sweetness, astringency and aroma increased. However, the change was not statistically significant ($P\geq0.05$). Reduce in sensory quality of fruit leather has been reported earlier, including declined in preference of taste and aroma [6], colour, texture, flavour and overall preference [7]. Similar to our result, aroma did not change to substantial extent, and it was the sensory characteristic that the least altered during storage [6]. Increase in sweetness of our product confirmed previous result where sugar concentration became higher in the storage [7]. This increase in sweetness by the progress of storage is an advantage, since sweetness is an important factor of fruit leather acceptance [4] [20]. Although statistically was not significant ($P\geq0.05$), the increase in astringency during storage should be given careful consideration for not adversely affect product preference. While lowering of sensory quality was apparent, its time stability may different for each product. Fruit leather without preservative would decline right in the second week [17], while those with addition of sucrose and acid showed noticeable change after 30 days [6]. Addition of acid and metabisulphite prolonged the storage stability of fruit leather up to 7 months [14].

Table 3. Statistical Significance of Treatments on Sensory Properties of Snake-Fruit Leather

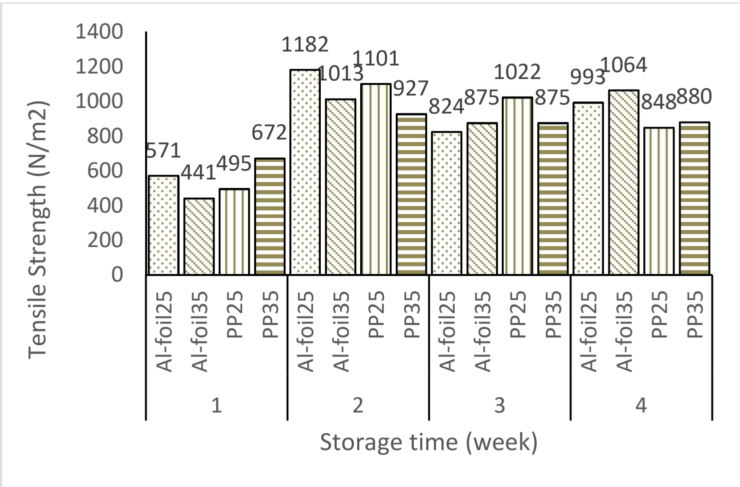
Parameters	Storage time	Type of packaging	Storage temperature
Hardness	0.127	0.475	0.752
Elasticity	0.767	0.680	0.508
Sweetness	0.125	0.751	0.247
Astringency	0.338	0.830	0.575
Aroma	0.051	0.171	0.335
Shininess	0.012	0.356	0.666
Cohesiveness	0.000	0.636	0.415

Note: not significant was P≥0.05, significant was P<0.05

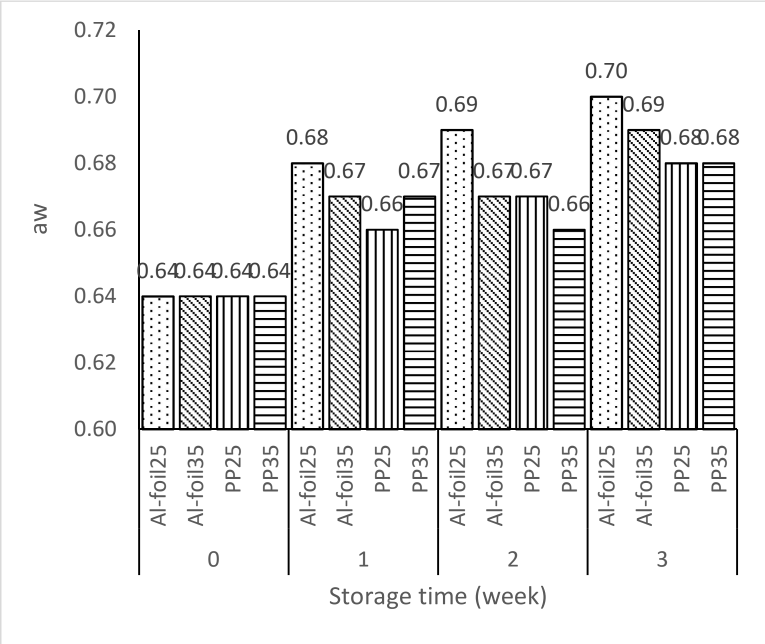
Table 4. Score for Sensory Evaluation of Snake-Fruit Leather

Parameters	Storage Time (Week)*			
	0	1	2	3
Hardness	5.28	4.87	5.02	4.48
Elasticity	4.94	4.86	4.79	4.59
Sweetness	4.90	5.20	5.34	5.58
Astringency	4.40	4.48	4.98	4.69
Aroma	5.32	5.41	6.09	5.74
Shininess	4.23b	3.19ab	3.60ab	2.98a
Cohesiveness	5.23ab	6.23b	5.66b	4.45a

*different superscripts in the same row indicated significant different (P<0.05)



(a)



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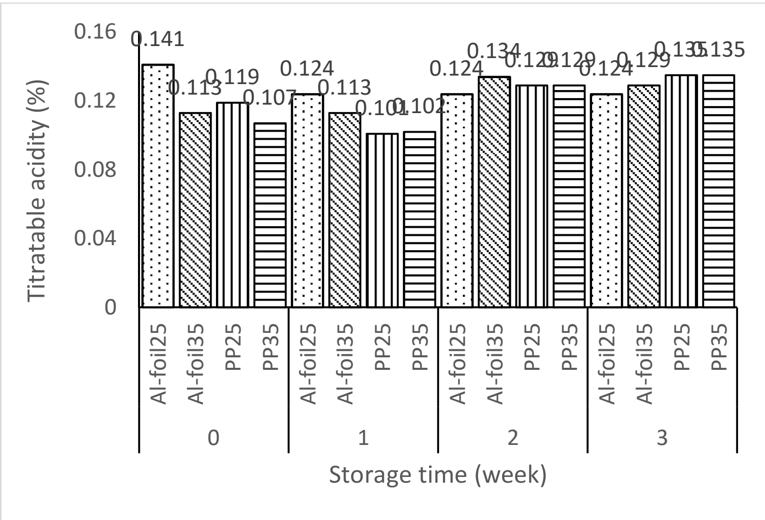

(c)

Figure 1. Effects of Storage Time on Tensile Strength (a), Water Activity (b), and Titratable Acidity of Snake-Fruit Leather

4. Conclusion and Recommendation/Policy Implication

Storage time was the main factor affecting physico-chemical and sensory characteristic of snake-fruit leather during storage, while type of packaging influenced chemical properties with laminated aluminium pouch gave better protection than polypropylene pouch. Storage temperature did not give considerable effect on fruit leather.

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Author contribution

UP and M designed the experiment, analysed the data, and wrote the manuscript. NWKP, AW, and ME carried out the laboratory works.

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