Development of Vegan Ice Cream from Jackfruit (*Artocarpus Heterophyllus*) Seed-based Milk

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Keywords: Crude Fiber, Food Product Development, Jackfruit Seed, Low-fat, Vegan Ice Cream.

Abstract: Modern lifestyle has initiated a vegan diet through the uptrend in plant-based or non-dairy milk that is subsequently incorporated in ice cream making. This research aimed to alter the under-utilized jackfruit seed into an alternative milk base for vegan, nutrient-rich ice cream. Jackfruit seeds were processed and filtered to obtain the liquid. A control and two variables of emulsifier [lecithin and surface perfectant (SP)] were formulated to produce ice cream. The ice cream was then analyzed for proximate analysis (crude fiber, total carbohydrate, fat, and protein content), physicochemical analysis (color and viscosity), followed by a 9-point hedonic scale acceptance test. Data were analyzed by analysis of variance (ANOVA) and Fisher's Least Significant Difference (LSD) test. Results showed that all ice cream formulations contained the beneficial crude fiber except for the commercial dairy ice cream. In addition, jackfruit seed-based milk ice cream was also low in fat content. Viscosity of lecithin-treated ice cream was significantly different ($p < 0.05$) compared to the others. Hedonic test (n=39) results showed that there were significant differences among the samples ($p < 0.05$) with the control group as the most preferred in terms of overall liking and flavor. In conclusion, changing dairy milk with jackfruit seed-based milk may deliver the potential creation of vegan, low-fat, and crude fiber-rich ice cream with reasonable consumer acceptability.

1 INTRODUCTION

Vegan ice cream is a type of ice cream that is made from non-animal based products, usually non-dairy milk, such as soy milk, coconut milk, almond milk, cashew milk, etc. Nowadays, plant-based or non-dairy milks are rising and fast growing as a trend in food development. Cow's milk allergy and lactose intolerance are some of the reasons for the consumers to choose vegan diet as an alternative (Sethi, Tyagi, and Anurag, 2016).

Jackfruit, one of the tropical fruits, has been used as a meat substitute in Indonesia, renowned for *gudeg*. Jackfruit flesh has been incorporated in many food products. However, reported publication about the beneficial use of jackfruit seed in food industry is scanty. Generally, the jackfruit seed is processed by boiling, steaming, or roasting to provide an economical source of protein, fiber, and minerals. Furthermore, the safety and toxicity studies (*in vivo*) of jackfruit seeds was conducted and it gave no physiological change in the behavior of the subjected animal (Suryadevara, Lankapalli, Danda, Pendyala, and Katta, 2017).

According to Suprapti (2004), jackfruit seed contains 4.2 g of protein, 0.1 g of fat, 36.7 g of carbohydrate, 33 mg of calcium, as well as other vitamins and minerals. Even though jackfruit seed contains a high value of starch, it is categorized as a low glycemic index (GI) food due to the role of dietary fiber and un-gelatinized starch granules. Therefore, it is good to be consumed as it does not strongly increase the glucose blood level (Hettiaratchi, Ekanayake, and Welihinda, 2011). In term of valuable health benefits, jackfruit seed is acknowledged to contain antioxidant prenylflavonoids along with the finding of isolated Jacalin for immune stimulation of human immunodeficiency virus HIV-1 infected patients (Suresh Kumar, Appukuttan, and Basu, 1982; Pereira-da-Silva *et al.*, 2006).

In addition, jackfruit seed-based ice cream can be consumed by those people suffering from lactose intolerance and it also contains dietary fiber for health bowel function by preventing constipation and

Lumbantobing, E., Tanardi, S. and Putra, A.
Development of Vegan Ice Cream from Jackfruit (Artocarpus heterophyllus) Seed-Based Milk.
DOI: 10.5220/0009983700002964
In *Proceedings of the 16th ASEAN Food Conference (16th AFC 2019) - Outlook and Opportunities of Food Technology and Culinary for Tourism Industry*, pages 66-71
ISBN: 978-989-758-467-1

lowering the risk of colorectal cancer. The nutritional value of jackfruit seed compared to cow's milk and soy milk can be seen in Table 1.

Table 1: Comparison of nutritional value of jackfruit seed, regular dairy cow's milk, and soy milk per 100 g.

Nutrient	Jackfruit seed†	Cow's milk‡	Soy milk‡
Carbohydrate (g)	38.40	4.8	3.45
Protein (g)	6.60	3.15	2.94
Dietary fiber (g)	1.50	0.00	0.40
Fat (g)	0.40	3.25	2.00
Ash (g)	1.25 - 1.50	0.70	1.80
Moisture (%)	51.60 - 57.77	88.13	90.98

Sources: †List of food ingredients composition, Directorate of Nutrition Department, RI Health, ‡USDA National Nutrient Database for Standard Reference.

The objective of the research was to manage the unusable waste to be a valuable and possible alternative food products and to utilize the jackfruit-seed-based milk as the main ingredient in vegan ice cream making which is also safe to be consumed by lactose-intolerance consumers.

2 METHOD

2.1 Sample Preparation and Jackfruit Seed Milk Making

Jackfruits (*Artocarpus heterophyllus*, purchased from a traditional market in Bandung, West Java) were separated into the flesh and seeds. The jackfruit seeds were soaked in 2% salt water (NaCl) with the addition of 5 drops of lemon juice. The soaked jackfruit seeds were filtered to separate from the water and cooked in a pressure cooker with the addition of water (ratio 1:1 w/v) for 1 minute, starting when the pressure regulator of pressure cooker emitted sound and released the steam. The jackfruit seeds were then cooled down to room temperature. After cooling down, the jackfruit seeds were weighed, and blended with water (ratio 1:1.5 w/v). The blended mixture was then filtered through cheesecloth into a glass jar. The jackfruit seed milk was then stored in a refrigerator at 4°C overnight.

2.2 Ice Cream Making

The ice cream was made with different emulsifiers as the variables: control group, SP group, and lecithin group. The ice cream formulation was stated in Table 2 below. The ice cream mixture was then homogenized. An ice cream maker was then set for 30 minutes to freeze the ice cream mixture. Final ice cream was stored in the freezer at -12°C.

Table 2: Ingredients used for ice cream formulation.

Ingredients	Sample		
	Control	SP	Lecithin
Jackfruit seed milk (mL)	200	200	200
Jackfruit juice* (as flavoring) (mL)	50	50	50
Coconut milk (Kara Sun) (mL)	50	50	50
Ground sugar (g)	20	20	20
Xanthan gum powder - stabilizer (Titan Baking Supply, Jakarta) (g)	1	1	1
SP (Koepoe Koepoe SP emulsifier) (g)	-	1	-
Lecithin (PT. United Chemicals Inter Aneka) (g)	-	-	1

*Note: the flesh of jackfruit was blended with water (ratio 1:1) to obtain the liquid.

2.3 Protein Analysis

Kjeldahl method approved by AOAC 930.33 (2000) was used to analyze the protein. The Kjeldahl machine used was Gerhardt ISO 8968-1. The calculation was done by the formula below.

$$\%\,N = \frac{(mL\ standard\ acid - mL\ blank)\ x\ N\ of\ acid\ x\ 1.4007}{weight\ of\ sample\ (g)} \quad (1)$$

2.4 Fat Analysis

Soxhlet method approved by AOAC 952.06 (2000) was used to analyze the fat content using Fat

Extractor Det-Gras-N (JP Selecta) machine. The fat content was calculated by the following formula.

$$\% \text{ Fat} = \frac{(weight\ of\ wet\ sample+thimble)-(weight\ of\ dry\ sample+thimble)}{(weight\ of\ wet\ sample+thimble)-(weight\ of\ thimble)} \times 100\% \quad (2)$$

2.5 Crude Fiber Analysis

Crude fiber analysis was conducted by the gravimetric method reapproved by AOAC 978.10 (2017). The crude fiber was calculated by the formula shown below.

$$\% \text{ Crude Fiber} = \frac{weight\ of\ fiber\ (g)}{weight\ of\ sample\ (g)} \times 100\% \quad (3)$$

2.6 Total Carbohydrate Analysis

Phenol-Sulfuric method, AOAC 988.12 (44.1.30), was used to analyze the total carbohydrate. Glucose standard solutions were prepared with the dilutions of 100, 200, 400, 600, 800, and 1000 µg/mL. The absorbance of samples were then read at 490 nm wavelength using a UV - VIS spectrophotometer (Shimadzu 1280).

2.7 Color Analysis

All ice cream mix samples were tested for the L*a*b* values using general colorimeter AMT-507 Kingwell.

2.8 Viscosity Analysis

All ice cream mix samples were subjected to Lamy Rotational Rheometer model First RM with thermal sensor (spindle no. 3, ASTM 3, 100 rpm, 30 seconds) to analyze and compare the viscosity.

2.9 Sensory Analysis

Three random codes (709: control, 881: SP, and 551: lecithin) were assigned for each sample. Forty one panelists were selected randomly from Indonesia International Institute for Life Sciences (i3L) with 18 and 23 of them were male and female, respectively. A 9-scale hedonic test was performed.

2.10 Statistical Analysis

IBM SPSS Statistics version 20 was used to conduct the statistical analysis. The sensory analysis result was analyzed by analysis of variance (ANOVA), followed by Fisher's least significant difference (LSD) test.

3 RESULT AND DISCUSSION

Ice cream sample was collected from the ice cream machine and then used for further analysis as the data shown and discussed below.

3.1 Proximate Analysis

As shown in Table 3, difference in protein content was found which indicated that both control and lecithin groups had higher protein content (3.04% and 1.23%, respectively) compared to that of SP (0.12%). The lecithin used in this experiment was soy lecithin which is the most common lecithin. Standard soy lecithin contains between 0.23% and 1.34% protein. According to Martín-Hernández, Bénet, and Marvin-Guy study (2005), this amount of protein in standard soy lecithin is higher compared to de-oiled soy lecithin (0.34%), sunflower lecithin from different supplier (0.89% and 0.41%), and egg lecithin (0.05%). Therefore, the ice cream with lecithin had higher protein content compared to that of SP.

Table 3: Proximate composition of jackfruit seed ice cream with different emulsifiers.

Proximate composition	Sample		
	Control	SP	Lecithin
Protein (%)	3.04	0.12	1.26
Fat (%)	0.19	7.77	0.20
Crude fiber (%)	0.59	0.94	0.80
Total carbohydrate (%)	0.24	0.28	0.24

In terms of fat content, SP group had a significant fat content (7.77%) compared to those of control and lecithin (0.19% and 0.20%, respectively). It is because of the utilization of Ryoto ester SP. Ryoto ester SP is one type of sucrose ester which is synthesized by esterification of fatty acids/natural glycerides with sucrose. Fatty acids in C8-C22 range are able to be reacted with sucrose to form esters with long chain fatty acids of palmitic (C16), oleic (C18), and stearic acid (C18). Thus, the highest fat content detected in ice cream with SP emulsifier supports the scientific theory stated by Nelen and Cooper (2004).

All ice cream samples contained crude fiber (Table 3) which came from jackfruit seed. Moreover, the jackfruit flesh itself was also used as the flavoring material. According to USDA (2016), the jackfruit flesh contains 1.5 g of dietary fiber (per 100 g of jackfruit). Compared to dairy ice cream, this jackfruit seed-based ice cream contains higher fiber. Regular dairy ice cream products found in the market contain 0% of fiber.

Through the equation with an excellent-fit R-squared value (0.99), the amount of total carbohydrate for each variable was calculated and there was no significant difference in total carbohydrate content between all variables. SP group had the highest total carbohydrate content (0.28%), meanwhile both control and lecithin groups had the same percentage of total carbohydrate (0.24%). These results showed that the use of emulsifier does not significantly affect the total carbohydrate content. Additionally, the amount of sugar used mostly determined the total carbohydrate content.

3.2 Physicochemical Analysis

The lightness of the ice cream was measured and shown in Figure 1 below. The result showed there is no significant difference in terms of lightness among samples.

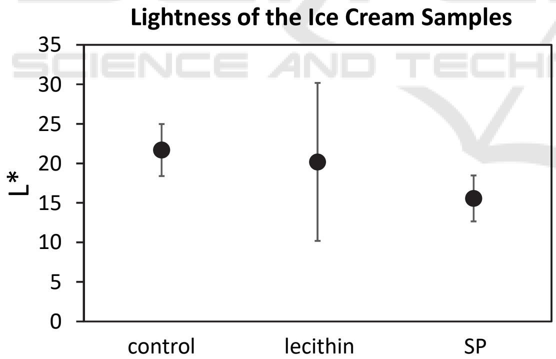

Figure 1: The lightness of the ice cream samples showed no significant difference between samples. The data were collected in two batches (independent measurement) with three replications in each batch.

Besides, the viscosity of the samples were also measured. As shown in Figure 2 the viscosity was significantly different ($p < 0.05$) with lecithin group had the highest viscosity, followed by SP group, and control group to be the lowest. These results indicate that emulsifier contributes the most on the rheological properties of the ice cream.

3.3 Sensory Analysis

According to Figure 3, the difference of each sample can be roughly seen in both overall liking and flavor attributes. On the other hand, the sweetness, smoothness, and consistency of the ice cream are not significantly different. Thus, subsequent one-way ANOVA and LSD test were conducted for all samples to find the difference among samples and the results were shown in Table 4.

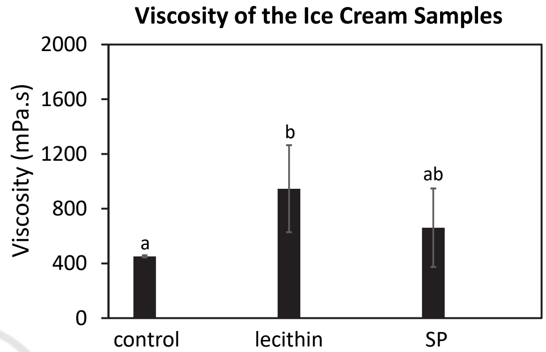

Figure 2: The viscosity of the ice cream samples ($p = 0.012$). The a and b indicate viscosity without common alphabet differ between samples ($p < 0.05$). The data were collected in two batches (independent measurement) with three replications in each batch.

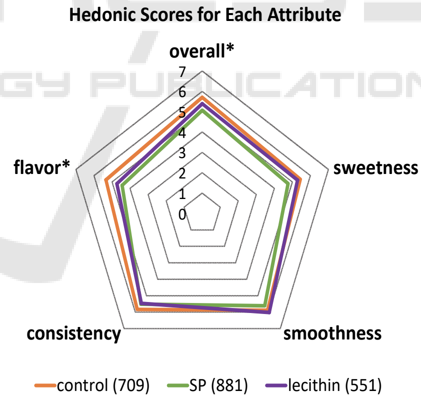

Figure 3: Spider chart of all jackfruit seed ice creams for five different attributes. Significant difference ($p < 0.05$) can be observed in overall liking and flavor.

Table 4: The result of consumer preference test.

Attribute	Control (709)	SP (881)	Lecithin (551)
Overall liking	5.82^{a}	5.13^{b}	5.46^{ab}
Flavor	5.49^{a}	4.44^{b}	4.79^{ab}

^{a,b} means of the attribute without a common superscript differ between the samples ($p < 0.05$).

The emulsifier indeed affects the overall liking attribute and the flavor of the ice cream ($p < 0.05$). Meanwhile the sweetness, smoothness, and consistency between all samples were not significantly different. According to Baer, Wolkow, and Kasperson (1997), the flavor of the ice cream should not be affected by the level of emulsifier used. The most preferred ice cream by overall liking and flavor was the control group, while the least preferred ice cream by overall liking and flavor was the SP group. Emulsifier might negatively affect the flavor of the ice cream (Baer, Wolkow, and Kasperson, 1997). According to the results above, consumers prefer the jackfruit seed ice cream without emulsifier. However, lecithin group was not significantly different compared with control group. Thus, lecithin group was also accepted by the consumers.

Certain properties of emulsifier are meant to enhance the whipping ability and product uniformity, improve meltdown resistance, and promote smooth texture as well as desirable mouthfeel. Emulsifier reduce the icy texture and coarse, as well as reduce the cold intensity of the ice cream (Baer, Wolkow, and Kasperson, 1997). All emulsifiers are made of a molecule with a mixture of both lipophilic and hydrophilic groups. The functionality of emulsifier towards the type of emulsion (either O/W or W/O) is highly determined by the Hydrophilic-Lipophilic Balance (HLB) numerical value. HLB is a number of the ratio between the balance of hydrophilic and hydrophobic groups of a surfactant. Nelen, Bax, and Cooper (2014) reported that a typical water-in-oil emulsions (W/O) require low HLB surfactants (3.5-6.0), meanwhile a higher HLB emulsifiers (8-18) are preferred for oil-water emulsion (O/W) which have more hydrophilic nature. Ryoto ester SP, as one type of sucrose esters, is water-soluble, resulting in higher HLB value (between 1-18) that contributes to the stabilization of ice cream in the O/W emulsion (Nelen and Cooper, 2004). As a commercial emulsifier, the type of fatty acids used somehow influences the properties of sucrose esters. The shorter the length of the fatty acid chain, the higher the HLB value.

It was also reported that due to the higher HLB value, sucrose ester is more suitable to develop better emulsion compared to lecithin due to its lower HLB value. In this experiment, the unknown type of fatty acid used in the SP might influence the functionality of the emulsifier towards ice cream mixture. Thus, the results of the sensory test was not as expected. There is no significant difference in terms of smoothness and consistency between the emulsifiers. The proper condition of ice cream samples during sensory test (i.e., ice cream temperature at serving, consistent quantity and physical appearance per sample) must be taken into consideration in order to obtain accuracy in the data.

4 CONCLUSIONS

Jackfruit seed can be used as the main ingredient for vegan ice cream. Jackfruit seed vegan ice cream contains crude fiber as its beneficial health effects. Moreover, the addition of different emulsifiers did not affect the lightness of the ice cream. Emulsifier mostly increases the ice cream's viscosity, which in turn, affects its sensorial properties with lecithin as the potential emulsifier in jackfruit seed vegan ice cream.

Further analysis such as iciness and coldness intensity should be included in the sensory evaluation. Additionally, microscopic analysis of the ice crystal should also be done.

ACKNOWLEDGEMENTS

Authors would like to express gratitude to the laboratory assistant members at Indonesia International Institute for Life Sciences (i3L).

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