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APPLICATION OF *Spirulina platensis* ON ICE CREAM AND SOFT CHEESE WITH RESPECT TO THEIR NUTRITIONAL AND SENSORY PERSPECTIVES

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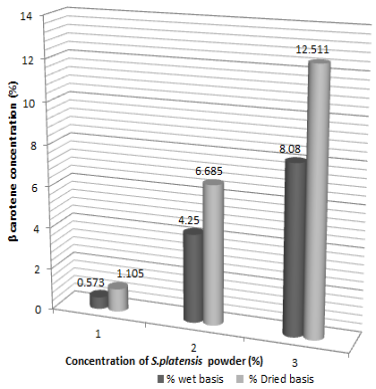
Graphical abstract



Abstract

Application of *Spirulina platensis* (Gomont) Geitler into food product can be used for producing functional food and improve its nutritional value. However, some bioactive compounds containing in *S. platensis* are heat sensitive, therefore processing techniques need to be strictly considered. It is necessary to observe the application of *S. platensis* powder into different products of ice cream and soft cheese in which the application of *S. platensis* was in relatively low temperature to protect its bioactive compounds from damage. *S. platensis* contains approximately 55 % to 70% of protein and its utilization on food product can be expected to improve the nutritional value. Innovation technique to produce such kind of product should respect to its acceptance by panelist using sensory test. Therefore, the objective of this research was to find out maximum concentration of *S. platensis* that can be added to the product and acceptable based on sensory and physical properties point of view. Experimental design used in this research was Completely Randomized Design with three replications. Data were analyzed using ANOVA and followed by HSD–test. The results showed that addition of 1 % and 1.2 % *S. platensis* were considered as the best concentration for soft cheese and ice cream, respectively. Addition of *S. platensis* gave significant effect to protein, water, fat, β carotene and texture (soft cheese) and protein, total solid, fat and total sugar, overrun, melting point and sensory (ice cream).

Keywords: Ice cream, physical properties, sensory, soft cheese, *Spirulina platensis* (Gomont) Geitler

1.0 INTRODUCTION

Application of *Spirulina platensis* (Gomont) Geitler is usually for food colorant due to its phycocyanin content. Some research have been conducted on antioxidant and anti-inflammatory properties of phycocyanin [1] stability of phycocyanin extract [2–4]. Therefore, *S. platensis* can also be used for functional food production due to its bioactive compounds which can improve nutritional value. However, some bioactive compounds containing in *S. platensis* are heat sensitive, therefore processing techniques need to be strictly considered.

Spirulina contains chlorophyll and carotenoids as well as phenolic and flavonoids compounds, which can act as natural substances [5]. In addition, *S. platensis* in the form of powder contains potential phenolic and flavonoid compounds. β-carotene contained in *S. platensis* is one of antioxidant which can neutralize free radical substances in human body and β-carotene is one of simple form of carotenoid with molecular formula of $C_{40}H_{56}$ [6, 7].

S. platensis is one of microalgae that is commonly utilized by people who live nearby water reservoir, or water with high salt concentration. *S. plantesis* harvested from sea water has higher mineral content compared to that of one harvested from fresh water and brackish water areas. Sea water contains high salt such as NaCl, KCl, MgCl. Spirulina cultivated in salted medium also contain phycocyanin, polysaccharide, inositol that are higher than the one from fresh water.

Cheese is milk–processed product that is produced by coagulation process of entirely or part of protein of milk, skim milk, butter milk, and whey cream by using rennet or other coagulation agent [8, 9].Ice cream is semisolid food that is made by freezing of milk, fat, sugar mixture with or without food additives [10]. Ice cream usually contains 0.2 % to 0.3 % stabilizer, 0.1% emulsifier, 10 % to 15 % sugar, flavor and coloring agent, 12 %, 4.1 % protein, 20.7 % carbohydrate and energy of 196.7 calorie per 100 g [11].

Commercial ice creams are lack of protein, easily melted and contains high fat. Therefore it is necessary to improve ice cream quality. Increase nutritional quality of ice cream and soft cheese can be done by certain food ingredient containing high nutritional value such as *S. platensis*. This microalga can be used as food source and be applied into some food products for example biscuit, paste, lozenges, jelly drink etc. [12].

This study was aimed to observe the application of *S. platensis* powder into two different products of ice cream and soft cheese in which the application of *S. platensis* was in relatively low temperature to protect its bioactive compounds from damage. According to Agustini *et al.*, the nutritional value of fresh *S. platensis* had significant difference compare to that of dried *S. platensis* [13]. Moreover, here is significant different quantitatively for its bioactive compounds. Maximum concentration of *S. platensis* that can be added to the product was determined, thus, will be acceptable for consumption.

2.0 EXPERIMENTAL

To prepare soft cheese, fresh milk (1 L) was heated at 70 °C for 15 min (Pasteurization) and was cooled to achieve temperature of 35 °C to 40 °C, added 5 mL acetic acid per 1 L milk, stirred for 15 sec. About ¼ tablets rennet was diluted in 1 mL water and added to a mixture of milk and acetic acid. Allow the milk added with rennet for 1 h to become fermented fresh cow milk and then cut so that they can be easily exerted, wait for 5 min. Fermented fresh cow milk was drained by using stainless steel bowl, and then poured hot water (30 mL) to accelerate the whey production and drained again. Compacted fermented fresh cow milk was then weighed according to the formulation (200 g). Salt (0.3 %) was added as well as *S. platensis* powder with different concentration (0 %, 0.5 %, 1 %, 1.5 %). The soft cheese resulted was then kept at refrigerated temperature for further analysis [14].

To prepare ice cream, egg yolk (3 %) and sugar cane (16 %) were mixed thoroughly to form foaming. Milk (45.5 %, 44.9 % and 44.3 %), skim milk (10 %), and gelatin (0.5 %) were heated at 60 °C. Then the mixture was poured into egg yolk and sugar cane mixture The mixture was then added with essence (10 %), and pasteurized at 85 °C for 10 min. Homogenized mixture was conducted while ice cream dough is still hot for 10 min at 1 500 rpm (1 rpm = 1/60 Hz). *S. platensis* powder was added at different concentration (0%, 0.6% and 1.2%). The final mixture of ice cream was then put in refrigerator (for aging process) until the temperature of 40 °C for 12 h. For ice cream maker, it takes only 15 min to get the final product. Packaging of Ice cream was conducted soon after removing from refrigerator / ice cream maker. Storing of the product was carried out at freezer at temperature of -18 °C for 24 h [15].

Protein content and fat content were analyzed for both products [16, 17]. Water content, Ash content, and β-carotene analysis were carried out for soft cheese [17, 18], while total solid, total sugar, overrun, melting point and hedonic test were carried out for ice cream [19-21].Experimental design used in this study was experimental laboratory by Completely Randomized Design with three replications for each treatment. Data obtained were then analyzed by ANOVA and follows by HSD test to see the different between treatments by using SPSS with significant level of 5 % [22].

3.0 RESULTS AND DISCUSSION

3.1 Soft Cheese

Nutritional value of soft cheese produced from this study was compared between control treatment (without *S. platensis* addition) and other treatments (with *S. platensis* addition) as presented in Table 1.

Table 1 Chemical analysis of soft cheese added with *S. platensis* powder (% w/w)

Parameter	Concentration of *S. platensis* powder (% w/w)		
	0*)	1.0*)	1.5*)
Water content (%)	48.17 ± 1.29[a]	36.42 ± 1.35[b]	35.41 ± 0.74[b]
Protein content (%)	3.79 ± 0.30[a]	16.44 ± 1.41[b]	22.62 ± 1.35[c]
Fat content (%)	3.16 ± 0.12[a]	3.31 ± 0.06[a]	3.46 ± 0.10[a]
Ash content (%)	2.37 ± 0.10[a]	2.55 ± 0.11[a]	2.46 ± 0.08[a]
β-carotene(%)	0.57 ± 0.12[a]	4.25 ± 0.77[b]	8.08 ± 0.84[c]

*)Value ± se

3.1.1 Proximate Analysis of Soft Cheese

Based on analysis of variance, soft cheese with addition of *S. platensis* powder with different concentration showed significant effect to water content of the samples ($P < 0.05$). *S. platensis* powder had fairly low water content which was less than10 %. According to Agustini *et al*., water content of *S. platensis* powder was 7.78 % [13]. Water content of the cheese was 35.41 % to 48.17 %, thus, it can be categorized as soft cheese. Water content of mozzarella cheese is 52.0 % to 60.0 % [23] or 46.0 % [24]. Increased concentration of *S. platensis* led to reduced water content of the samples. According to Mardiani, less water content of soft cheese resulted in longer shelf life of the product [25].

There is significant difference on protein content of samples due to addition of *S. platensis* powder ($p < 0.005$). High protein content in *S. platensis* powder in the range of 55 % to 75% [26], 6 % to 62% [27], 60 % to 71% [28], 69 % to 74% [13] has resulted in increasing protein significantly on the product. During processing of soft cheese, *S. platensis* powder was added at 30 °C, to avoid denaturation process on protein. Protein can denature due to heating at 60 °C to 70 °C [29]. Protein content of the samples with addition of *S. platensis* in the range of 16.44 % to 22.62 % is consistent with protein content of soft cheese 18 % to 20 % [30] and 17 % [31].

There was no significant different on fat content of the soft cheese before and after addition of *S. platensis* ($P > 0.005$). Fat content of *S. platensis* powder is relatively low 2.64 % [13], 5.6 % to 7 % [32], 6 % to 6.5 % [12]. Due to low amount of *S. platensis* powder addition (0 % to 1.5 %), the treatment had no effect on fat content of the product.

There was a significant difference on ash content of the soft cheese before and after addition of *S. platensis* powder ($P < 0.005$). This occurrence was affected by ash content of *S. platensis* powder which was 10.66 % to 11.56 % [13]. Ash content of the product was comparable to Mozzarella cheese from Italy of which the concentration was 2.3 % [33] and 1 % to 3 % [34]. Increased ash content of soft cheese with addition of *S. platensis* powder was due to relatively high ash content of *S. platensis*. Sodium content also increased due to salt addition during processing as well as whey excretion cause by acidification process

3.1.2 β-carotene

Significant increase of β-carotene was found on the product added with *S. platensis* powder. Higher concentration of *S. platensis* led to higher β-carotene concentration in the product ($P < 0.005$). *S. platensis* contains high amount of β-carotene (26.74 %), moreover, the content which was about 700 mg kg^{-1} to 1 700 mg kg^{-1} in dried *S. platensis* [32, 35]. β-carotene of *S. platensis* powder was not significantly damaged during processing because it was mixed with fermented cow milk at 30 °C in order to prevent degradation [35]. According to Aisyah, high temperature can reduce the number of β-carotene and it is susceptible towards oxygen exposure and leads to enzymatic oxidation by lypoxygenase enzyme thus destroy β-carotene molecules [36]. Furthermore, it is obvious that β-carotene is also vulnerable towards light exposure and is sensitive to temperature higher than 60 °C. Cosequently, isometric change occured from trans- into cis-β-carotene which was more unstable [7]. β-carotene is one of natural antioxidant that can prevent illness because it can neutralize free radicals substances inside human body which can promote the existence of degenerative diseases [37]. *S. platensis* has also been used for fortification on chocolate bar to increase its β-carotene content with concentration up to 5 % (w/w), while β-carotene content of soft cheese produced in this research was 7 mg per 100 g [38]. According to FAO, β-carotene intake of 6 mg d^{-1} can reduce cancer risk for human [12].

3.2 Ice Cream

Nutritional value of ice cream produced from this study was compared between control treatment (without *S. platensis* addition) and other treatments (with *S. platensis* addition) as presented in Table 2.

3.2.1 Total Solid

Total solid replaced amount of water in the product, hence increased nutritional value and improve texture of the product. Higher total solid of ice cream led to fewer amount of water added to the product. According to Hadiwiyoto, total solid covers all component include carbohydrate, fat, protein, vitamin and minerals [39]. Total solid of the samples was consistent with standard of National Standardized Agency [4], i.e. 3.4 % (w/w). Maximum total solid of ice cream is 42 %, and if it is more than

42 %, it can give effect to weight and humidity of the product [11].

Table 2 Chemical analysis of ice cream added with *S. platensis* powder (% w/w)

Parameter	Concentration of *S. platensis* powder (% w/w)		
	0*)	0.6*)	1.2*)
Total Solid (%)	32.89 ± 0.23[a]	34.54 ± 0.96[b]	34.82 ± 0.73[b]
Protein content (%)	3.23 ± 0.08[a]	3.48 ± 0.07[b]	3.54 ± 0.14[b]
Fat content (%)	7.41 ± 0.26[a]	7.28 ± 0.21[a]	6.76 ± 0.25[b]
Total sugar (%)	24.33 ± 1.16[a]	21.97 ± 0.55[b]	21.27 ± 0.61[b]

*)Value ± se

3.2.2 Protein Content

Based on protein content, the ice cream product can be categorized as high protein ice cream. This is due to high protein content from *S. platensis* powder. Protein content of *S. platensis* was around 55 % to 70 % [40] and 67.18 % to 72.85 % [13]. There is significant difference on protein content of ice cream before and after addition of *S. platensis*. Increasing protein content after addition of *S. platensis* was due to high protein content of *S. platensis* powder, thus increasing nutritional value of the ice cream. During homogenization, protein content in milk as well in *S. platensis* might be coagulated and denatured. Pasteurization at 60 °C to 70 °C can lead to protein coagulation [41] and heating may also lead to protein denaturation [29].

3.2.3 Fat Content

The ice cream product in this study can be categorized as low fat ice cream because the source of the fat was from fresh milk, egg yolk and whipping cream. There is no significant difference on fat content among the treatments ($P > 0.005$). *S. platensis* has fat content of 4 % to 6% [27] and 2.64 % to 2.86 % [13]. Therefore,this product is suitable for low–fat diet.

3.2.4 Total Sugar

According to National Standardization Agency, minimum sugar content (sucrose) of ice cream should be 8 % [10]. Sugar content of the ice cream (with and without addition of *S. platensis*) was quite high, and there is significant difference before and after addition of *S. platensis*. Addition of *S. platensis* powder tend to reduce total sugar of the product, on the other hand, total solid of the product increased with addition of *S. platensis* powder. This high total sugar of the product is still consistent with standard (Indonesian National Standard-SNI)

Table 3 Physical analysis of Ice cream added *S. platensis*

Parameter	Concentration of *S. platensis* powder (% w/w)		
	0*)	0.6*)	1.2*)
Overrun (%)	33.99 ± 0.28	35.25 ± 1.10	37.62 ± 0.58
Melting (min per 10 g)	21.38 ± 0.88	24.26 ± 0.98	28.08 ± 0.98

*)Value ± se

3.2.5 Overrun

Overrun can be defined as increased volume of ice cream dough due to entrapped air during mixing and freezing inside ice cream maker [20]. Figure 3 shows that *overrun* of ice cream with addition of *S. platensis* powder tend to be higher compared to that of without addition of *S. platensis* powder. Protein can increase consistency and softness of ice cream. During homogenization, addition of *S. platensis* powder can increase foam volume compared to that without addition of *S. platensis*. Addition of protein rich substances into ice cream could increase foam volume because more air was entrapped inside the ice cream dough and consequently increased its volume [42]. Different overrun could be occurred because each processing steps had different air trapping effect during freezing [43].

3.2.6 Melting

Addition of *S. platensis* increased melting point of ice cream. Melting point is time required for ice cream to be completely melted. Melting point of ice cream is affected by total solid [11]. The rate of melting generally depends on the existence of stabilizer agent, emulsifier agent, ratio of salt and other substances as well as processing and storing [20]. Generally, ice cream should not melt at room temperature, but quickly melts at human body temperature. The longer time required for ice cream to melt at room temperature means that the ice cream is more stable. Therefore, ice cream with very low melting point usually has hard texture. Addition of *S. platensis* powder resulted in low melting point compared to that of without addition of *S. platensis*. High concentration of *S. platensis* addition led to increasing resistance of melting point. In addition, *S. platensis* has other effect on increasing viscosity and texture of ice cream.

3.2.7 Hedonic Test

Hedonic test is determined by panelist and it is based on subjective method [44]. Hedonic test of the ice cream can be seen on Table 4.

Table 4 Hedonic test of Ice cream with addition of *S. platensis powder*

Parameters	Concentration of *S. platensis* powder (% w/w)		
	0*)	0.6*)	1.2*)
Aroma	7.10 ± 0.66	6.60 ± 0.85	6.23 ± 1.07
Color	7.27 ± 0.52	6.93 ± 0.64	6.0 ± 1.22
Texture	7.03 ± 0.81	6.97 ± 1.09	6.70 ± 0.91
Taste	7.10 ± 0.96	6.97 ± 0.89	6.46 ± 1.13

*)Value ± se

Color and appearance are considered as the dominant factor for food quality. Odor is one of specification which determines consumer preference. Volatile compounds are responsible for odor. Based on hedonic test, odor of ice cream in the range of 6.60 ± 0.85 (for 0.6 %) and 6.23 ± 1.07 (for 1.2 %). However, panelist preferred ice cream without addition of *S. platensis* (7.10 ± 0.66). Odor of ice cream is determined mostly by fat in milk. S. *platensis* addition will give additional odor that is tend to be fishy or unpleasant. Fishy odor of *S. platensis* is coming from its minerals content [29]. Kurskall-Wallis test showed that *Chi square*18.085 > *Chi Square*$_{table}$ 5.991, so that addition of *S. platensis* gave significant difference to odor of ice cream.

Hedonic test for color of ice cream with addition of *S. platensis* were 6.93 ± 0.64 (for 0.6 %) and 6.0 ± 1.22 (for 1.2 %). Color of ice cream should be attractive for consumer. Panelists preferred ice cream without addition *S. platensis* (7.27 ± 0.52). This phenomenon suggested that panelists preferred lighter green color (ice cream added with *S. platensis* had dark green color). Higher amount of *S. platensis* addition gave darker green color to the ice cream due to blue–green pigment (phycosianin) in *S. platensis* [29]. Kurskall-Wallis test showed that *Chi square*34.497 > *Chi Square*$_{tabel}$ 5.991, indicated that addition of *S. platensis* gave significant effect on color of ice cream.

Texture of ice cream is affected by ice crystal which was formed during processing. Ice cream with smooth texture could only be formed when ice crystal size is small, on the other hand, the texture will be if the crystal was big. Texture of ice cream depends on the size of ice crystal which is dispersed into air crystal, so that ice cream will have specific texture and taste [11]. Texture of ice cream is determined by total solid, sugar concentration and viscosity [47].

Taste of ice cream is detected by taste receptor (tongue). Ice cream is usually sweet and this factor will determine whether ice cream is accepted or not by consumer. In order to increase nutritional value of ice cream, *S. platensis*is added especially for protein and phycocyanin content. However, addition of *S. platensis* could give effect on taste of ice cream, therefore it is necessary to know the suitable concentration of *S. platensis* addition to obtain nutritional increase while still acceptable from sensory perspectives. Flavor of ice cream is combination of taste and odor [45]. Quality and taste of ice cream is affected by sugar, stabilizer, and dried non–fat matter. Factors affecting panelist on taste include chemical substances, temperature, concentration of total solid and interaction with other taste compounds. Product with unpleasant taste will not be accepted by consumer even if other parameters such as color, texture and odor are still acceptable [46].

4.0 CONCLUSION

The results showed that addition of 1 % and 1.2 % *S. platensis* were considered as the best concentration for soft cheese and ice cream, respectively. Addition of *S. platensis* gave significant effect to protein, water, fat, β-carotene and texture (soft cheese) and protein, total solid, fat, total sugar, overrun, melting point and sensory (ice cream).

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