Studii şi Cercetări Ştiinţifice 2019, **20** (2), pp. 151 – 165
Chimie şi Inginerie Chimică, Biotehnologii, Industrie Alimentară

Scientific Study & Research
Chemistry & Chemical Engineering, Biotechnology, Food Industry *ISSN 1582-540X*

ORIGINAL RESEARCH PAPER

EFFECT OF BAKING SODA ADDITION ON THE CHARACTERISTIC OF ICE CREAM FROM COW'S MILK

Angela Nitia Nefasa[1,2], Marcelinus Christwardana[3*], Hadiyanto[4], Nurwantoro[2], Sri Mulyani[2]

[1]Boyolali University, Faculty of Animal Husbandry, Department of Animal Husbandry, 57315, Boyolali, Indonesia
[2]Diponegoro University, Faculty of Animal Husbandry, Department of Livestock Technology, 50275, Semarang, Indonesia
[3]Institut Teknologi Indonesia, Department of Chemical Engineering, 15320, South Tangerang, Indonesia
[4]Diponegoro University, Faculty of Engineering, Department of Chemical Engineering, 50275, Semarang, Indonesia

*Corresponding author: marcelinus@iti.ac.id; mchristwardana@gmail.com

Received: July, 12, 2018
Accepted: April, 17, 2019

Abstract: The effect on the properties of ice cream from cow's milk from the addition of different concentrations of baking soda (0, 0.2, 0.4, 0.6, and 0.8 wt %) was investigated. The ice cream was consumed by 25 panelists to evaluate the sensory properties of the ice cream. The ice cream with the addition of 0.6 wt % baking soda showed an insignificant change of antioxidant activity during the pasteurization process (only a decrease of 10.01 %) and while having good physical properties such as viscosity (923 ± 28.45 cP), overrun (54.16 ± 0.40 %), and *p*H (7.23 ± 0.06). Furthermore, the addition of 0.6 wt % baking soda into the ice cream also had insignificant effect on the melting time and color. The presence of CO_2 bubbles due to $NaHCO_3$ led to the formation of small cavities that made the ice cream texture creamer and softer due to the weak bond between the ice cream crystals and other materials such as sugar, fat, and protein. In general, ice cream with the addition of 0.6 wt % baking soda received good acceptability or response from respondents, which means that baking soda can be used as an additive material of ice cream.

Keywords: *baking soda, cow's milk, ice cream, physical analysis, sensory analysis*

© 2019 ALMA MATER Publishing House, "VASILE ALECSANDRI" University of Bacău. All rights reserved.

INTRODUCTION

Ice cream is a frozen sweetened processed product that is very popular in the world [1]. Ice cream is usually made from dairy products which are composed of milk, sweeteners, emulsifiers, stabilizers and often combined with fruits or other flavoring ingredients. It can be considered as an aerated suspension of fat and water in a concentrated sugar solution including stabilizers, casein micelles, and proteins [2]. The intended fat content is usually derived from animal/cream only, although there are some types of ice cream products that still use basic vegetable fats and fruits. Throughout history, there have been several inventions related to the existence of ice cream, such as the combination of ice with salt to increase the melting time, the ice cream maker invention, and eventually, the invention of the refrigerator in the 19th century [3].

In addition to its popularity, ice cream contains a complete nutritional value. According to Deosarkar *et al.* [4], the composition of 100 grams of plain ice cream consists of 61.7 % water, 4.1 % protein, 12 % fat, 20.7 % carbohydrate, and 1.5 % additional ingredients. Almost all vitamins contained in ice cream include A, B (B_1, B_2, B_6, B_{12}), C, D, E, K, the highest amount being registered for vitamins A, C, and B_2 [4]. Besides vitamins, ice cream made from milk also contains natural antioxidants, including conjugated linoleic acid, α - tocopherol, β - carotene, coenzyme Q_{10}, phospholipids, and peptides, where these antioxidants have a key role in maintaining pro-oxidants and antioxidant homeostasis and in the human body [5].

Even though the addition of salt is usually used to increase the melting time of ice cream, some innovations to extend melting time need to be increased to respond to consumer needs. Ullah *et al.* [6] reported that the addition of sugarcane juice could increase the melting time of ice cream from 15.75 to 16.74 minutes. Kurt and Atalar [7] had added quince seed powder to increase the melting time from 80 to 90 minutes, while Da Silva *et al.* [8] used *Bifidobacterium animalis* as probiotics for the same purpose. In addition, some researchers add additional ingredients to increase nutrient content in ice cream; for instance, Balthazar *et al.* [9] added probiotics to ice cream, while Rizzo *et al.* [10] added coconut and sunflower oil as ingredients. In addition, to increase the nutritional content of ice cream, the presence of additional ingredients aim to improve antioxidant functions, flavor, and texture.

Baking soda, or sodium bicarbonate ($NaHCO_3$), is widely used in the food industry at levels of up to 2 % for leavening, *p*H control, flavor, and texture development [11]. As a cake-baking agent, bicarbonate releases carbon dioxide gas bubbles from baking dough during the roasting process [12]. Besides this, baking soda also has a function to bind cake forming components [13]. According to Yao *et al.* [14], baking soda can also be used for biocontrol efficacy in fruit. In another case, baking soda can be used to absorb any odors, such as the bad odor that comes from soured milk [15].

The process of pasteurization in dairy products is usually done at 80 °C [3, 16], therefore pasteurization is also used in the ice cream preparation process to remove undesirable bacteria. The pasteurization process used in making ice cream may also affect the antioxidant content. Commonly, a heated process is used as a method for milk security and stability, and it can be responsible for quality changes such as color distortion, enzyme inactivation, nutrient modification, and antioxidant depletion [17 – 20].

In this study, the effect of baking soda on ice cream is investigated to determine the chemical properties (antioxidant content) and physical properties (overrun, melting time, viscosity and *p*H), and sensory quality (flavor, texture, color, and consumer acceptance). With the properties of baking soda as a baking and binding material, coupled with its relationship with antioxidants, the melting time and antioxidant content of the ice cream is expected to remain in a good range. In addition, based on several other properties of baking soda, it is anticipated that baking soda can improve the quality of sensory aspects of the ice cream. This research is expected to provide benefits in the form of information about the right concentration of baking soda to obtain the best quality ice cream.

MATERIALS AND METHODS

Materials

In this study, cow's milk cream and milk skim powder were obtained from a local market in Semarang. Sugar and egg act as sweetener and emulsifier, respectively, where only egg yolk would be used as an emulsifier. Carboxyl Methyl Cellulose (CMC) as a stabilizer was purchased in a supermarket in Semarang, while baking soda ($NaHCO_3$) as additional material was bought from the local chemical market also in Semarang. Other materials for analysis such as 2-diphenyl-1-(2,4,6-trinitrophenyl)hydrazyl (DPPH) and methanol were purchased from Sigma Aldrich (St. Louis, USA).

The process of making ice cream

The making of the ice cream was conducted in Livestock Technology Laboratory, Department of Animal Husbandry, Diponegoro University. Initially, ice cream was created by mixing 59.2 g of milk cream, 30.2 g of skim milk powder, 37.9 g of sugar, 0.93 g of CMC, 5.9 g of egg yolk, and 165.9 g of water for a total of 300 g of dough. Afterward, various baking soda concentrations of 0.2, 0.4 0.6, and 0.8 wt % of total dough mass was added into the dough and mixed for 2 minutes. The dough was then pasteurized using a low-temperature long time (LTLT) method at 60 °C for 15 minutes by using a water-bath DLAB DWB 20-P (Beijing, China) and was then cooled to 25 °C. After that, the dough was homogenized by using a Phillips 1552 hand mixer (Amsterdam, Netherlands) for 10 minutes. While the mixing process continued for 20 minutes, a mixture of ice cubes and salt was added to the exterior surroundings of the dough container in order to replace the role of an ice cream maker. In this condition, the temperature of the system decreased from 25 to 10 °C during the 30 minutes of mixing. The aging process was conducted by storing the dough in a refrigerator at 4 °C for 12 hours. Finally, the ice cream was stored in a freezer at -10 °C. A sample of ice cream without the addition of baking soda was used as a control (C).

Physical properties analysis

The overrun analysis was obtained by weighing the ice cream dough before and after freezing, and calculated according to equation (1):

$$overrun\,(\%) = \frac{W_2 - W_1}{W_1} \times 100 \quad (1)$$

where W_1 and W_2 is the weight of ice cream dough before and after freezing, respectively.

Melting time analysis was conducted by leaving a 40 g sample of ice cream at 25 °C. Prior to the analysis, the sample was prepared by storing the ice cream dough in the freezer for two days. Measurement of melting time began once the ice cream was removed from the freezer until all of the ice cream melted. The analysis was performed in quadruplicate. A Brookfield viscometer DV1 (Massachusetts, USA) with an RV spindle set No. 2, was used to determine the viscosity of ice cream dough, while the *p*H of the ice cream dough was analyzed using a digital *p*H meter Ohaus Starter 300 (New Jersey, USA).

Antioxidant activity measurement

DPPH radical scavenging capacity was used to determine the antioxidant activity of the ice cream with and without the addition of baking soda. The method of DPPH scavenging effect was selected due to its simple, fast, easy, accurate, reliable, and practical screening technique. About 1 mL of ice cream sample was added into 1 mL of 0.1 mM DPPH (in methanol), and then 3 mL of methanol was fed into the mixture solution until the total solution was 5 mL. The mixed solution was then incubated for 1 hour under dark condition, while a similar mixture without ice cream sample was used as a blank solution. The samples were then analyzed using a UV–Vis spectrophotometer Optima SP-300 (Tokyo, Japan) at 515 nm [21]. The % DPPH scavenging effect was calculated by the following equation (2):

$$DPPH\ scavenging\ effect = \frac{A_{blank} - A_{sample}}{A_{blank}} \times 100\,\% \quad (2)$$

Sensory analysis

The sensory evaluation of the ice cream was conducted at the Department of Animal Husbandry, Diponegoro University by 25 students acting as panelists, consisting of 12 males and 13 females with an age range between 20 and 22 years, and all panelists without any training before. The panelists used a score test for flavor, texture, color and consumer acceptance. The sensory characteristics were judged based on whether or not a panelist liked or disliked the ice cream with the following scale: 1 as disliked very much, 2 as disliked moderately, 3 as liked, 4 as liked moderately, and 5 as liked very much. The ice cream was coded to hide the ice cream treatment to the panelists, and the list of codes is shown in Table 1.

All panelists were encouraged to write the comments and suggestions about which ice cream they considered useful for further research.

Table 1. *The code of ice cream*

No	$NaHCO_3$ [wt %]	Code
1	0	461
2	0.2	552
3	0.4	734
4	0.6	866
5	0.8	258

Color measurement

A colorimeter (Konica Minolta CR-400 Chroma Meter, Tokyo, Japan) was used to measure the color of the ice cream dough with and without the addition of baking soda. The colorimeter was calibrated before measuring the samples by using a white reference tile. The L^*, a^*, b^* coordinates (L^* for lightness, a^* for red-green and b^* for yellow-blue) were determined using a CIE scale, and color change (E^*) was obtained by the following equation (3):

$$\Delta E = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^2} \tag{3}$$

where ΔE^* is the color change, ΔL^* is the difference in L^* with and without baking soda, Δa^* is the difference in a^* with and without with baking soda, and Δb^* is the difference in b^* with and without baking soda. While according to Gomes *et al.* [22], chromaticity and hue angle were calculated with the following equations (4) and (5):

$$\Delta E = \sqrt{a^{*2} + b^{*2}} \tag{4}$$

$$Hue\ angle = \tan^{-1}\left(\frac{b^*}{a^*}\right) \tag{5}$$

The analysis was performed in triplicate.

Design of experiment and statistical analysis

The experimental design to be used in this study was Completely Randomized Design (CRD) with 5 treatments and 4 replications. For the sensory analysis test, 25 panelists participated. A mathematic model which can be applied in this experiment is shown in the following equation (6):

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij} \tag{6}$$

where Y_{ij} is the observations of the i-th treatment and the j-th repetition, μ is median, α_i is the effect of the i-th treatment, and ε_{ij} is the effect of experimental error arising on the i-th treatment and the j-th repetition. The statistical data were calculated by using SPSS statistical software where analysis of variance and Duncan's Multiple Range Test was used to determine significant differences among the results.

RESULTS AND DISCUSSION

Effect of baking soda on physical characteristics of ice cream

It is important to analyze the physical characteristics of ice cream in respect to various baking soda concentrations because of the relationship to the bonding of air, sugar, fat, ice crystal, and water in the ice cream [23, 24]. As can be seen from Table 2, the viscosity of ice cream with 0.2 wt % of baking soda added was higher than other samples, while the lowest value of viscosity was in the case of ice cream with 0.8 wt % of baking soda added with a value of 1564 and 806 cP, respectively. The viscosity value of ice cream dough with 0, 0.4 and 0.8 wt % added were 1016, 1066, and 923 cP, respectively. Addition of baking soda in the ice cream dough resulted in carbonic acid which caused small bubbles. In the case of ice cream with the addition of 0.2 wt % of baking soda, bubbles could be removed during the mixing process, which caused the viscosity of ice cream dough to increase. While with more than 0.2 wt % addition of baking soda, small bubbles inside the ice cream dough could not be removed during the mixing process which made the viscosity slightly decrease.

Table 2. *Viscosity, overrun, and pH of ice cream dough*

$NaHCO_3$ [wt %]	Viscosity [cP]	Overrun [%]	*p*H
0	1016 ± 80.67	44.12 ± 0.34	6.94 ± 0.05
0.2	1564 ± 67.19	46.06 ± 0.68	7.08 ± 0.02
0.4	1066 ± 66.81	50.36 ± 0.16	7.15 ± 0.08
0.6	923 ± 28.46	54.16 ± 0.40	7.26 ± 0.06
0.8	806 ± 53.33	60.46 ± 0.71	7.56 ± 0.07

Beside the viscosity, the addition of baking soda in ice cream dough affects the overrun of the ice cream. Overrun of ice cream is the increase of ice cream volume during the agitation or mixing process. Ice cream which has no overrun will have a form like a hard lump. From Table 2 it can be concluded that the increase of baking soda concentration also enhances the overrun, although, with the addition of 0.2 wt % of baking soda, the overrun increase was insignificant. The overrun value of ice cream dough with the addition of 0, 0.2, 0.4, 0.6, and 0.8 wt % baking soda were 44.12, 46.06, 50.36, 54.16, and 60.46 %, respectively. All of the ice cream samples had lower overrun values (44.12–60.46%) compared to the values reported in the literature (80 - 120 %) [25]. These results are compatible with literature wherein the baking soda is usually used as a baking agent. Overrun is related to a decrease in system surface tension which consisted of air and water due to the absorption of protein molecules [26].

The effect of the addition of baking soda on ice cream melting time can be shown in Figure 1. Ice cream with the addition of 0.2 wt % baking soda had a higher value of melting time than compared to other samples, with a value of 13.82 ± 0.64 minutes. The melting time of ice cream with the addition of 0, 0.4, 0.6, and 0.8 wt % of baking soda were 13.27 ± 0.69, 13.2 ± 0.65, 12.3 ± 0.67, 11.97 ± 0.87 minutes, respectively.

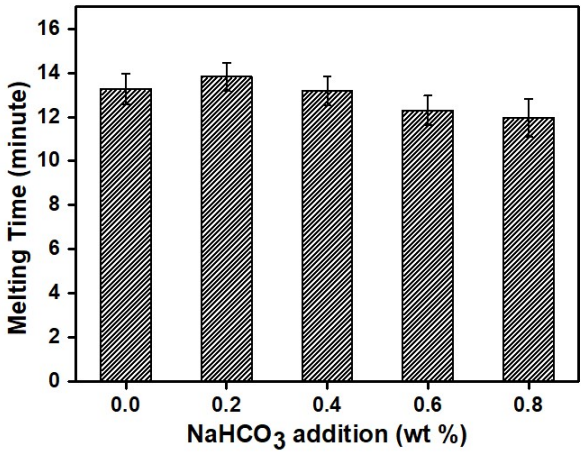

Figure 1. *Effect of baking soda addition on melting time of milk's cow ice cream (error bars show Standard Deviation)*

The addition of baking soda resulted in an insignificant effect in increasing the melting time of ice cream ($P > 0.05$). In the presence of 0.2 wt % baking soda in the ice cream dough, baking soda will bind and react with water in the dough to form NaOH and H_2CO_3 which increases the rate of the Maillard reaction during pasteurization due to an increased *p*H [27]. During the pasteurization, H_2CO_3 easily evaporates because it is a volatile material [28], and the small bubbles of H_2CO_3 (trapped CO_2 in H_2O) could be reduced during the mixing process as previously explained, which made the dough of the ice cream have a higher viscosity than the control (without any addition of baking soda), compatible with Table 2. On the other hand, small cavities left by CO_2 can increase the bond between molecules (fat, sugar, protein) in ice cream so that the melting rate could be decreased (melting time increased) [29, 30]. Unfortunately, when baking soda was fed at more than 0.2 wt %, the melting time slightly decreased due to an abundance of CO_2 in the ice cream since H_2CO_3 is CO_2 trapped in the water. The small bubbles would leave the small cavities in the dough during the pasteurization process and didn't disappear during the mixing process. Small cavities would clearly form during the aging and freezing processes, which could decrease the bonding between the ice crystals and other materials (fat, sugar, protein) in the ice cream. The weak bonding between fat and other components made the ice cream easier to melt [31]. Sofjan and Hartel [25] reported that ice cream with lower overrun and viscosity usually has a lower melting time or higher melting rate. In the case of the sample with 0.2 wt % baking soda added, small bubbles could be removed easily during the homogenization process.

Effect of baking soda on antioxidant activity of ice cream

The effect of the addition of baking soda on ice cream antioxidant activity before and after pasteurization process is an important quality to be investigated. According to Espin *et al.* [32], DPPH is a stable free radical that would be scavenged by a proton-donating substance, for instance, an antioxidant. The antioxidant activity of ice cream expressed by DPPH scavenging effect both before and after the pasteurization process is shown in Figure 2.

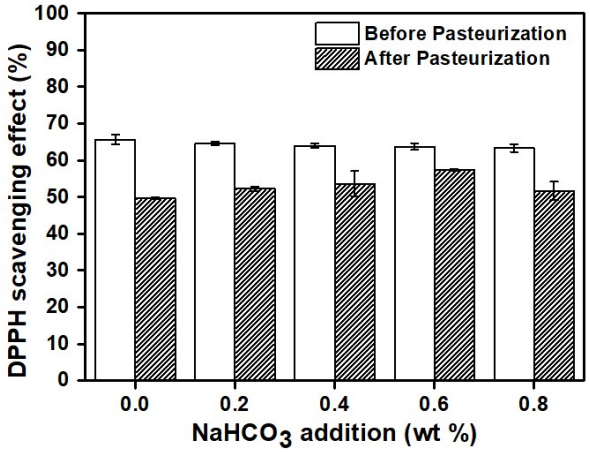

Figure 2. *Effect of baking soda addition on DPPH scavenging effect of milk's cow ice cream (error bars show Standard Deviation)*

From Figure 2, there are three noticeable things which can be explained regarding the antioxidant activity. First, in the condition before the pasteurization process, as the addition of baking soda concentration increases, the DPPH scavenging effect slightly decreased but it was insignificant within the range of 62 - 67 %. This result means the addition of baking soda didn't have an effect on the ice cream antioxidant activity in the initial process. Second, increasing the baking soda concentration in the ice cream dough up to 0.6 wt % can maintain the antioxidant activity at a higher level. The antioxidant activity of ice cream dough with the added 0, 0.2, 0.4 and 0.6 wt % of baking soda decreased by 24.36, 19.01, 16.11, and 10.01 % respectively. This result means that the addition of baking soda plays a role to keep the antioxidant activity high during the pasteurization process and this can become a new advantage in cow's milk ice cream. Third, unfortunately, the addition of 0.8 wt % of baking soda couldn't maintain a high antioxidant activity, as the antioxidant activity reduction was 18.45 % from its initial activity (before the pasteurization process). This may have been due to the change of structure related to antioxidant components derived from cow's milk such as omega-3, omega-6, etc.

Sensory evaluation on ice cream added with baking soda

Besides affecting the physicochemical properties, baking soda can also effect the sensory properties of milk's cow ice cream such as its color, texture, and flavor (Figure 3). The result of the effect of adding baking soda to the sensory properties of pasteurized milk can be seen in the next discussion.

Color evaluation on ice cream

Color is important to be investigated because it is related to the aesthetic and attractiveness factor of ice cream. According to Figure 3a, the highest score was obtained when 0.6 wt % of baking soda was added into the ice cream dough with a score of 3.88 ± 0.53. The scores of ice cream with the addition of 0, 0.2, 0.4, and 0.8 wt % baking soda were 3.56 ± 0.65, 3.52 ± 0.87, 3.68 ±0.48, and 3.72 ± 0.61, respectively.

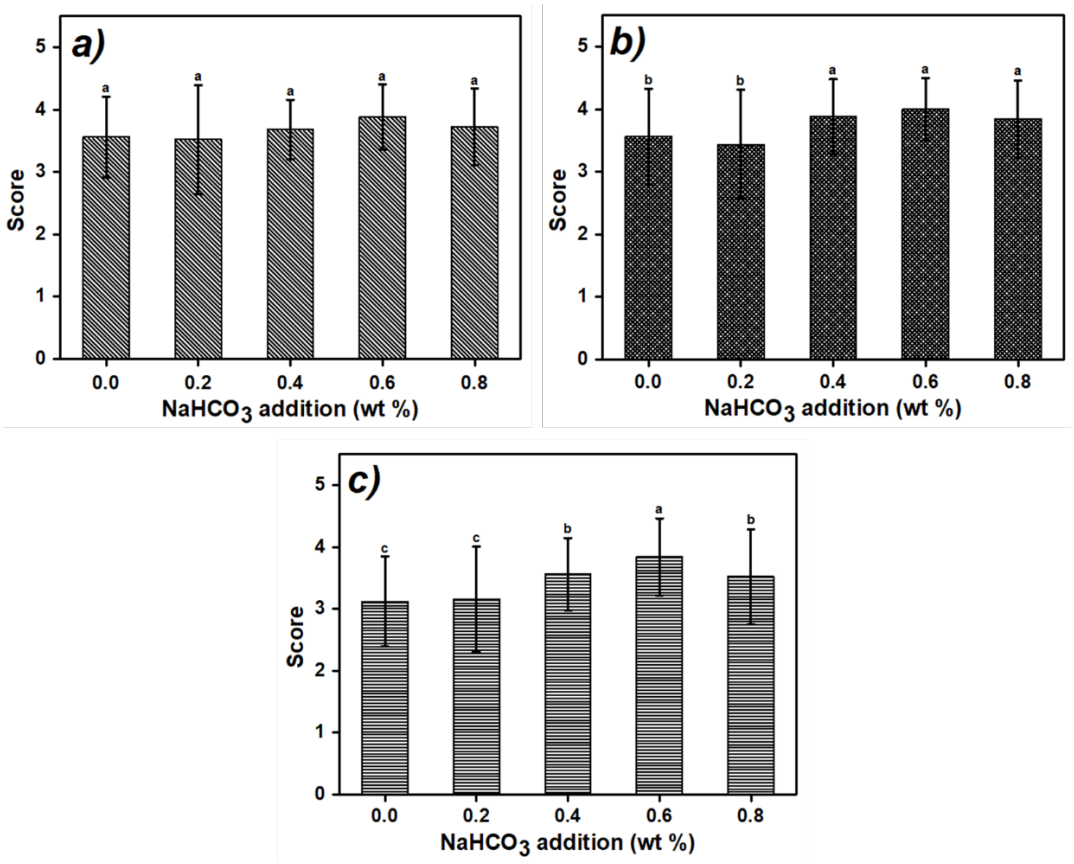

Figure 3. *Effect of baking soda addition on color (a), texture (b) and flavor (c) of milk's cow ice cream (error bars show Standard Deviation and superscript letters are significantly different (p > 0.05))*

Ice cream with an added 0.2 wt % had the lowest score because the color had turned a slightly yellowish tone which was caused by the low bonding between fat and sugar [33, 34]. Fortunately, the addition of baking soda didn't change the color of ice cream due to the natural white color of baking soda as shown in Table 3.

Table 3. *Color parameters for ice creams associated with different baking soda addition*

$NaHCO_3$ [wt %]	L*	a*	b*	ΔE*	H^O	C*
0	73.67 ± 0.58	-25.00 ± 0.00	52.33 ± 0.58	0.00 ± 0.00	115.53 ± 0.27	58.00 ± 0.52
0.2	73.33 ± 1.15	-23.67 ± 0.58	53.33 ± 0.58	1.80 ± 0.26	113.94 ± 0.32	58.35 ± 0.77
0.4	72.33 ± 0.58	-23.00 ± 1.00	53.67 ± 1.53	3.53 ± 0.55	113.23 ± 1.51	58.40 ± 1.01
0.6	71.00 ± 1.00	-22.33 ± 0.58	54.33 ± 1.15	4.33 ± 0.30	112.34 ± 0.13	58.74 ± 1.28
0.8	70.67 ± 1.15	-22.33 ± 1.15	55.33 ± 0.58	5.23 ± 0.38	111.95 ± 0.60	59.67 ± 1.50

According to Table 3, the value of L* was around 70.67 - 73.67, which indicates that the color is lighter. Addition of baking soda did not significantly affect a* value where the value range -25 to -22.33, which means samples containing more baking soda have a less blue-green color composition compared to the control. As the baking soda concentration increases, b* value also increased with the range was 52.33 - 55.33,

meaning that the baking soda addition made the color composition more yellow compared to the control. The combination of L*, a*, b* values were then plotted in a CIE color scale, and the color of the ice cream was white with a little bit of grey. From L*, a*, b* results, the value of ΔE* can be calculated, and as the baking soda increased, the potency of color change also increased although not significantly. Table 2 also shows that all samples with and without the baking soda addition possessed a hue angle with a range of 111.95 to 115.53°, which means the yellow/green region. C* indicates the degree of saturation, purity, or intensity of visible color [35]. The value of C* in this experiment was in the range of 58 - 59.67. The average score for all samples was 3.67 ± 0.64 with criteria from 'liked to 'liked moderately'. The inconspicuous color difference in ice cream with the addition of baking soda also resulted in an insignificant analysis value ($P > 0.05$). According to Spence *et al.* [36] and Elliot and Maier [37], color has an influence on flavor perception of humans. Since this ice cream is made from cow's milk, the white color of ice cream is more suitable.

Texture evaluation on ice cream

The texture of ice cream is one of the most important things to be studied because it will affect the perception of respondents about its acceptability. In some studies, the texture of ice cream is related to its hardness. The effect of baking soda on ice cream texture can be shown in Figure 3b, where the highest score obtained was when 0.6 wt % of baking soda was added into the ice cream dough, with the score was 4 ± 0.5. The lowest score (3.44 ± 0.87) was recorded when 0.2 wt % baking soda was fed into the ice cream dough. The score of texture from ice cream with the addition of 0, 0.4, and 0.8 % of baking soda were 3.56 ± 0.77, 3.88 ± 0.6, and 3.84 ± 0.62, respectively. The average score of texture from all samples was 3.74 ± 0.71, with the criteria from 'liked to 'liked moderately'. Statistically, the addition of baking soda made a significant effect on the texture of ice cream which can be shown from the value of p, which was less than 0.05. With the addition of 0.2 wt % baking soda, the baking soda could bond with water which then resulted in the formation of NaOH and H_2CO_3. This formation made the viscosity of dough increase but resulted in small cavities from trapped CO_2 in water (H_2CO_3) which were reduced during the mixing process. So, the obtained ice cream texture was harder than other samples, especially the ice cream sample without the addition of $NaHCO_3$. As the concentration of baking soda in the ice cream dough increased, the resulted H_2CO_3 also increased and thus became more challenging to be removed during the homogenizing process. The small cavities inside of the ice cream dough would be formed during the aging and freezing processes, and it made the texture of ice cream softer. In the case of ice cream with the addition of 0.8 wt % of baking soda, respondents didn't like the texture because it was too soft compared to the ice cream with the addition of 0.6 wt % of baking soda. The softness of the ice cream is directly proportional with the overrun [38 – 40]. Ice cream dough with a low viscosity means that it also has a high overrun which makes the texture of the ice cream softer. This result is compatible with the results presented in Table 1. According to some references, the carbohydrate content affects the softness of ice cream; although it can also increase the melting rate [29, 41, 42]. Moreover, the bonding between the ice crystals and other materials became a factor which affected the hardness or softness of ice cream [43].

Flavor to evaluation on ice cream

It is essential to investigate the flavor of ice cream because it is an important factor which affects the 'value' of food [44]. The score from respondents related to ice cream flavor with the added concentrations of baking soda is displayed in Figure 3c. From this figure, the highest score (3.84 ± 0.62) was obtained from the ice cream with 0.6 wt % of baking soda added while the lowest score (3.12 ± 0.73) was for the ice cream without any addition of baking soda. The score of the ice creams with the additional 0.2, 0.4, and 0.8 wt % of baking soda were 3.16 ± 0.85, 3.56 ± 0.58, and 3.52 ± 0.77, respectively. The average score of all sample was 3.44 ± 0.76 with the criteria from 'liked' to 'liked moderately' and, statistically, the addition of baking soda would not affect to the flavor of ice cream significantly ($p > 0.05$). This is beneficial for consumers that may want the flavor of milk to be maintained. Since baking soda has no distinctive aroma and flavor, the presence of baking soda will not change the milk flavor of the ice cream. With the addition of $NaHCO_3$, a bond is formed with water, thus producing NaOH and H_2CO_3. Since H_2CO_3 is a weak acid and it will decompose into H_2O and CO_2, it will not have a noticeable effect on the *p*H of ice cream. Conversely, the presence of NaOH in the ice cream increased the *p*H of the ice cream by a small amount without changing the flavor. With the addition of 0.2 wt % baking soda, an increase in the *p*H of the ice cream dough from the baking soda gave an insignificant effect, but the sample with the additional 0.6 wt % of baking soda had an increase in the flavor of milk in the ice cream, and most of the respondents liked this flavor. However, too much added baking soda (0.8 wt %) in the ice cream dough made the flavor a little more bitter because the *p*H of the ice cream changed to base [45, 46], and most respondents did not like this bitter flavor.

Consumer acceptance

To determine the general preference of the panelists for the ice cream with the addition of baking soda, consumer acceptance needs to be studied, as shown in Figure 4.

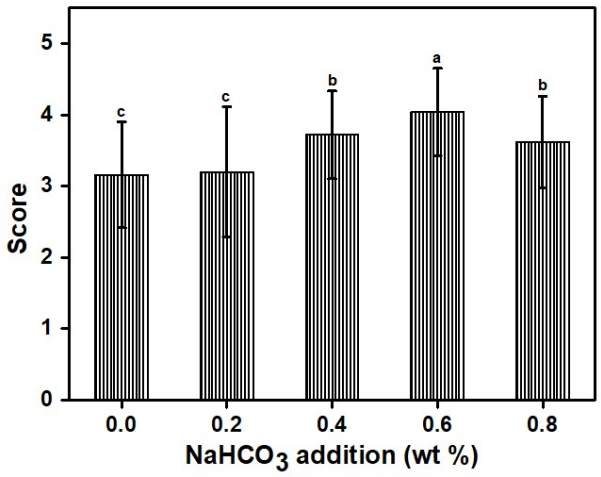

Figure 4. *Effect of baking soda addition on consumer acceptance of milk's cow ice cream (error bars show Standard Deviation and superscript letters are significantly different ($p < 0.05$))*

Most panelists liked the ice cream with the addition of 0.6 wt % baking soda with a score of 4.04 ± 0.61. With the addition of 0.6 wt % baking soda, no discoloration was observed in the ice cream. So, there is a preference toward the white color, good flavor of cow's milk, and a soft texture for ice cream. This texture was caused by the small cavities left behind by CO_2 gas, even though the melting time decreased due to the weak bonding between the ice crystals and other materials (sugar, protein, fat). A slightly harder texture and a little bit of a sour flavor – due to the presence of lactic acid bacteria (LAB) – in the ice cream without baking soda and in the ice cream with the addition of 0.2 wt % baking soda had a more or less similar score of consumer acceptance with scores of 3.16 ± 0.75 and 3.16 ± 0.91, respectively. The score of consumer acceptance for the ice cream with the addition of 0.4 and 0.8 wt % of baking soda were 3.72 ± 0.61 and 3.64 ± 0.64, respectively. The average score of consumer acceptance for all samples was 3.55 ± 0.78 with criteria from 'liked to 'liked moderately,' and with a p-value less than 0.05 had a significant effect and the complete score for all sensory analysis can be shown in Figure 5 where ice cream with 0.6 wt % of baking soda dominated. From the previous results, the ice cream with the addition of 0.6 wt % baking soda is acceptable and even marketable for commercial purpose in the future.

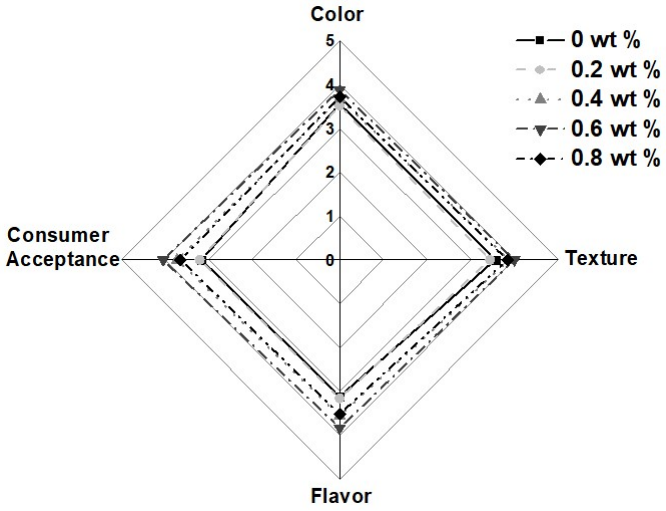

Figure 5. *Effect of baking soda addition on sensory analysis of milk's cow ice cream (error bars show Standard Deviation and superscript letters are significantly different ($p < 0.05$))*

CONCLUSIONS

The addition of baking soda to produce ice cream from cow's milk can be an alternative solution to enhance its quality. The presence of 0.6 wt % baking soda can improve the physical and sensory properties of the ice cream. The direct effect of the addition of baking soda with this concentration is that it can maintain high antioxidant activity by showing a high DPPH scavenging effect after the pasteurization process. It also has a good viscosity (923 ± 28.45 cP), good overrun (54.16 ± 0.40 %), and can maintain the ice cream dough in neutral *p*H range (7.26 ± 0.06), although it does slightly decrease the melting time from 13.27 ± 0.69 to 12.3 ± 0.67. The addition of baking soda also has no

significant effect on the color of the ice cream and as seen from the L*, a*, and b* measurements, the color of the ice cream samples is a light white with a little bit of grey. The addition of baking soda made the texture of the ice cream softer and creamier due to the small cavities from CO_2 bubbles that weaken the bonding between ice crystals and other ice cream materials such as fat, sugar, and protein. There was no flavor change with the addition of baking soda and the predominant flavor was still that of the cow's milk. Overall, ice cream from cow's milk with the addition of 0.6 wt % baking soda has the general acceptance to be consumed by people.

ACKNOWLEDGMENTS

The authors thank the Livestock Technology Laboratory, Department of Animal Husbandry, Diponegoro University and Center of Biomass and Renewable Energy (C-BIORE) Diponegoro University for their facilities.

REFERENCES

1. El Owni, O.A.O., Zeinab, K.O.K.: Chemical composition of ice cream produced in Khartoum state, Sudan, *Pakistan Journal of Nutrition*, **2009**, **8** (2), 158-160;
2. Koxholt, M.M., Eisenmann, B., Hinrichs, J.: Effect of the fat globule sizes on the meltdown of ice cream, *Journal of Dairy Science*, **2001**, **84** (1), 31-37;
3. Clarke, C.: *The Science of Ice Cream*, RSC Publishing, London, **2015**;
4. Deosarkar, S.S., Kalyankar, S.D., Pawshe, R.D., Khedkar, C.D.: Ice Cream: Composition and Health Effects, in: *Encyclopedia of Food and Health* (Editors: Caballero, B., Finglas, P.M., Toldrá, F.), Academic Press, Oxford, **2016**, 385-390;
5. Grażyna, C., Hanna, C., Adam, A., Magdalena, B.M.: Natural antioxidants in milk and dairy products, *International Journal of Dairy Technology*, **2017**, **70** (2), 165-178;
6. Ullah, R., Nadeem, M., Ayaz, M., Tayyab, M., Imran, M., Sajid, R.: Antioxidant characteristics of ice cream supplemented with sugarcane (*Saccharum officinarum* L.) juice, *Food Science and Biotechnology*, **2015**, **24** (4), 1227-1232;
7. Kurt, A., Atalar, İ.: Effects of quince seed on the rheological, structural and sensory characteristics of ice cream, *Food Hydrocolloids*, **2018**, **82**, 186-195;
8. Da Silva, P.D.L., de Fátima Bezerra, M., dos Santos, K.M.O., Correia, R.T.P.: Potentially probiotic ice cream from goat's milk: Characterization and cell viability during processing, storage and simulated gastrointestinal conditions, *LWT-Food Science and Technology*, **2015**, **62** (1), 452-457;
9. Balthazar, C.F., Silva, H.L.A., Celeguini, R.M.S., Santos, R., Pastore, G.M., Conte Junior, C.A., Freitas, M.Q., Nogueira, L.C., Silva, M.C., Cruz, A.G.: Effect of galactooligosaccharide addition on the physical, optical, and sensory acceptance of vanilla ice cream, *Journal of Dairy Science*, **2015**, **98** (7), 4266-4272;
10. Rizzo, G., Masic, U., Harrold, J.A., Norton, J.E., Halford, J.C.G.: Coconut and sunflower oil ratios in ice cream influence subsequent food selection and intake, *Physiology & Behavior*, **2016**, **164**, 40-46;
11. Lindsay, R.C.: Food Additives, in: *Food Chemistry* (Editor: Fennema, O.R.), Marcel Dekker., Inc., New York, **1985**, 629-688;
12. Kocer, D., Hicsasmaz, Z., Bayindirli, A., Katnas, S.: Bubble and pore formation of the high-ratio cake formulation with polydextrose as a sugar- and fat-replacer, *Journal of Food Engineering*, **2007**, **78** (3), 953-964;
13. Ciullo, P.A.: *Baking Soda Bonanza*, 2nd edition, HarperCollins Publishers, Pymble (Australia), **2009**;

14. Yao, H., Tian, S., Wang, Y.: Sodium bicarbonate enhances biocontrol efficacy of yeasts on fungal spoilage of pears, *International Journal of Food Microbiology*, **2004**, **93** (3), 297-304;
15. Lansky, V.: *Baking Soda: Over 500 Fabulous, Fun, and Frugal Uses You've Probably Never Thought of*, Book Peddlers, Minnesota, **2009**;
16. Udabage, P., Augustin, M.A., Cheng, L.J., Williams, R.P.W.: Physical behaviour of dairy ingredients during ice cream processing, *Le Lait*, **2005**, **85** (4-5), 383-394;
17. Renner, E.: Storage stability and some nutritional aspects of milk powders and ultra high temperature products at high ambient temperatures, *Journal of Dairy Research*, **1988**, **55** (1), 125-142;
18. Ma, D., Shu, G., Chen, H., Zhang, J., Xin, N., Meng, J.P.: Effects of different sugars, alcohols, antioxidants on goat milk tablets containing *Lactobacillus acidophilus* LA-5, *Scientific Study & Research - Chemistry & Chemical Engineering, Biotechnology, Food Industry*, **2018**, **19** (3), 231-242;
19. Schaafsma, G.: Effects of heat treatment on the nutritional value of milk, *Bulletin of the International Dairy Federation*, **1989**, **238**, 68-70;
20. Pearce, R.J.: Thermal denaturation of whey protein, *Bulletin of the International Dairy Federation*, **1989**, **238**, 17-23;
21. Gómez-Alonso, S., Fregapane, G., Salvador, M.D., Gordon, M.H.: Changes in phenolic composition and antioxidant activity of virgin olive oil during frying, *Journal of Agricultural and Food Chemistry*, **2003**, **51** (3), 667-672;
22. Gomes, W.F., Tiwari, B.K., Rodriguez, Ó., de Brito, E.S., Fernandes, F.A.N., Rodrigues, S.: Effect of ultrasound followed by high pressure processing on prebiotic cranberry juice, *Food Chemistry*, **2017**, **218**, 261-268;
23. Ko, S.H., Han, Y.S., Yoon, H.G., Jang, S.S., Myoung, K.S., Kim, S.A., Shim, J.H., Park, S.Y., Lee, H.J., Lee, K.Y.: Quality characteristics of ice creams using Tarak, *Korean Journal of Culinary Research*, **2014**, **20**, 91-101;
24. Erkaya, T., Dağdemir, E., Şengül, M.: Influence of Cape gooseberry (*Physalis peruviana* L.) addition on the chemical and sensory characteristics and mineral concentrations of ice cream, *Food Research International*, **2012**, **45** (1), 331-335;
25. Sofjan, R.P., Hartel, R.W.: Effects of overrun on structural and physical characteristics of ice cream, *International Dairy Journal*, **2004**, **14** (3), 255-262;
26. Thaiudom, S., Singchan, K., Saeli, T.: Comparison of commercial stabilizers with modified tapioca starches on foam stability and overrun of ice cream, *Asian Journal of Food Agro Industry*, **2008**, **1** (01), 51-61;
27. Lertittikul, W., Benjakul, S., Tanaka, M.: Characteristics and antioxidative activity of Maillard reaction products from a porcine plasma protein–glucose model system as influenced by pH, *Food Chemistry*, **2007**, **100** (2), 669-677;
28. Adrogué, H.E., Adrogue, H.J.: Acid-base physiology, *Respiratory Care*, **2001**, **46** (4), 328-341;
29. Souza, J.C.B., Costa, M.R., de Rensis, C.M.V.B., Sivieri, K.: Sorvete: composição, processamento e viabilidade da adição de probiótico, *Alimentos e Nutrição*, **2010**, **21** (1), 155-165;
30. Prapasuwannakul, N., Boonchai, S., Pengpengpit, N.: Use of green coconut pulp as cream, milk, stabilizer and emulsifier replacer in germinated brown rice ice cream, *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering*, **2014**, **8** (5), 462-465;
31. Muse, M.R. Hartel, R.W.: Ice cream structural elements that affect melting rate and hardness, *Journal of Dairy Science*, **2004**, **87** (1), 1-10;
32. Espín, J.C., Soler-Rivas, C., Wichers, H.J., García-Viguera, C.: Anthocyanin-based natural colorants: a new source of antiradical activity for foodstuff, *Journal of Agricultural and Food Chemistry*, **2000**, **48** (5), 1588-1592;
33. Guinard, J.-X., Zoumas-Morse, C., Mori, L., Panyam, D., Kilara, A.: Effect of sugar and fat on the acceptability of vanilla ice cream, *Journal of Dairy Science*, **1996**, **79** (11), 1922-1927;
34. Guinard, J.X., Zoumas - Morse, C., Mori, L., Uatoni, B., Panyam, D., Kilara, A.: Sugar and fat effects on sensory properties of ice cream, *Journal of Food Science*, **1997**, **62** (5), 1087-1094;
35. Calvo, C.: Optical properties, in: *Handbook of Food Analysis. Physical Characterization and Nutrient Analysis* (Editor: Nollet, L.M.L.), vol. 1, Marcel Dekker, Inc., New York, **2004**, 1-19;
36. Spence, C., Levitan, C.A., Shankar, M.U., Zampini, M.: Does food color influence taste and flavor perception in humans?, *Chemosensory Perception*, **2010**, **3** (1), 68-84;

37. Elliot, A.J., Maier, M.A.: Color psychology: Effects of perceiving color on psychological functioning in humans, *Annual Review of Psychology*, **2014**, **65**, 95-120;
38. Goff, H.D., Freslon, B., Sahagian, M.E., Hauber, T.D., Stone, A.P., Stanley. D.W.: Structural development in ice cream - dynamic rheological measurements, *Journal of Texture Studies*, **1995**, **26** (5), 517-536;
39. Wilbey, R.A., Cooke, T., Dimos, G.: Effects of solute concentration, overrun and storage on the hardness of ice cream, in: *Ice Cream: proceedings of the international symposium* (Editor: Buchheim, W.), International Dairy Federation, Brussels, **1998**, 186-187;
40. Tanaka, M., Pearson, A.M., de Man, J.M.: Measurement of ice cream texture with the constant speed penetrometer, *Canadian Institute of Food Science and Technology Journal*, **1972**, **5** (2), 105-110;
41. Mosquim, M.C.A.: *Fabricando Sorvete com Qualidade*, Fonte Comunicações e Editora, Varela, São Paulo, **1999**;
42. Pinheiro, M.V.S., Penna, A.L.B.: Substitutos de gordura, tipos e aplicações em produtos lácteos, *Alimentos e Nutrição*, **2004**, **15** (2), 175-186;
43. Sakurai, K., Kokubo, S. Hakamata, K., Tomita, M., Yoshida, S.: Effect of production conditions on ice cream melting resistance and hardness, *Milchwissenschaft*, **1996**, **51** (8), 451-454;
44. Balthazar, C.F., Silva, H.L.A., Cavalcanti, R.N., Esmerino, E.A., Cappato, L.P., Abud, Y.K.D., Moraes, J., Andrade, M.M., Freitas, M.Q., Sant'Anna, C., Raices, R.S.L., Silva, M.C., Cruz, A.G.: Prebiotics addition in sheep milk ice cream: A rheological, microstructural and sensory study, *Journal of Functional Foods*, **2017**, **35**, 564-573;
45. Soukoulis, C., Tzia, C.: Grape, raisin and sugarcane molasses as potential partial sucrose substitutes in chocolate ice cream: A feasibility study, *International Dairy Journal*, **2018**, **76**, 18-29;
46. Kanta, A., Soukoulis, C., Tzia, C.: Eliciting the sensory modalities of fat reformulated yoghurt ice cream using oligosaccharides, *Food and Bioprocess Technology*, **2018**, **11** (4), 885-900.