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ARTICLE

Comparison of General Characteristics and Functional Properties of Soft Ice Cream Made with Whey By-Products and Lotus Leaf Extract

Jin-Young Yoon[1†], Yoh-Chang Yoon[2†], Kwang-Young Song[3*]

[1]Graduate School of Agriculture and Animal Science, Konkuk University, Seoul, Korea
[2]Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul, Korea
[3]Department of Companion Animal Health and Department of Pet Industry, Daegu Hanny University, Gyeongsan, Korea

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†These authors contributed equally to this study.

*Corresponding author :
Kwang-Young Song
Department of Companion Animal Health and Department of Pet Industry, Daegu Hanny University, Gyeongsan, Korea
Tel : +82-53-819-1605
Fax : +82-53-819-1273
E-mail : drkysong@gmail.com

ORCID
Jin-Young Yoon
https://orcid.org/0009-0008-9270-0667
Yoh-Chang Yoon
https://orcid.org/0009-0001-9056-3012
Kwang-Young Song
https://orcid.org/0000-0002-5619-8381

Abstract

This study aimed to address consumer demand for health-functional foods by using natural, health-promoting raw materials in ice cream, a widely popular food. Soft ice cream was manufactured using lotus leaf extract and whey by-product WPC-35 (whey protein concentrate with 35% protein content), and its characteristics were examined. The lotus leaf extract was prepared by soaking lotus leaf powder in ethanol, concentrating it, and freeze-drying the solution into a powdered form. WPC-35 is a whey protein powder containing 35% protein. The analysis revealed that the lactose content of soft ice cream with WPC-35 was 5.93%, higher than that of soft ice cream with lotus leaf extract. Moisture content was 68.2% in soft ice cream with WPC-35 and 65.6% in soft ice cream with lotus leaf extract, showing higher moisture in the WPC-35 variant. No significant difference in ash content was observed between the two types of ice cream. The protein content and emulsifying activity were both slightly higher in soft ice cream with WPC-35 compared to that with lotus leaf extract. Antioxidant activity, measured by electron-donating ability using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) method, was higher in soft ice cream with lotus leaf extract (92%) than in soft ice cream with WPC-35 (85.7%). In the sensory evaluation, the overall preference score for soft ice cream with lotus leaf extract was 3.9 points, surpassing the score for soft ice cream with WPC-35.

Keywords

soft ice cream, lotus leaf extract, whey protein concentrate (WPC)-35, functionality, sensory evaluation

Introduction

Well-being is a lifestyle that pursues a happy life through a healthy body and mind in harmony with the busy daily life of modern people, instant food, and stress [1]. And well-being is a term that emphasizes the quality of life with the meaning of living a healthy (well, satisfactory) life (being). Therefore, this pursuit of well-being is also appearing as a phenomenon that upgrades the value, enjoyment, and functionality of food in addition to the general functions of food such as energy and nutrients in the diet [1].

The world including Korean frozen dessert market is growing in size as the demand for eating out and snacking has increased since COVID-19 [2,4]. It is expected to continue the battle for leadership through low-sugar and functional ice cream products for health-conscious consumers in the future.

According to the Korea Agro-Fisheries & Food Trade Corporation (aT) food industry

statistics in January 2024, the size of the Korean frozen dessert market based on retail sales in 2023 was calculated to be KRW 1,453,181 million [4]. This is a 4% increase from KRW 1,393,865 million in the same period last year [4]. This shows that ice cream has established itself as a major food item in Korea [4]. Since ice cream is made from milk fat and milk solids, it is a source of nutritional value and bioactive substances contained in milk [3,5]. In addition, efforts are being made to simultaneously satisfy the functionality of food and consumer preference by using natural ingredients that are beneficial to health in ice cream [5]. For example, research is being conducted on the production of high-quality ice cream with various added functions, such as nut meat ice cream, mulberry leaf ice cream, odi ice cream, soybean & soy yogurt ice cream, citron extract ice cream, soy yogurt ice cream, and so on [6-12].

The lotus (*Nelumbo nucifera*) is a dicotyledonous plant belonging to the floating plants among aquatic plants, and is native to southern Asia and northern Australia [13,14]. It mainly grows in ponds and is also cultivated in rice fields [15]. It is a Paleozoic plant widely distributed in tropical and temperate eastern Asia, including Korea and Japan, centered around India and China, and is generally considered a sacred plant in Buddhism [13-15]. Until now, the flowers have been used as ornamental and tea ingredients, and the leaves and roots have been used for food [16]. In particular, the lotus leaf has a bitter taste and a mild nature, and has been used as a folk remedy for hemorrhagic gastric ulcers, gastritis, hemorrhoids, bleeding, diarrhea, headaches & dizziness, hemoptysis, postpartum hematuria treatment, enuresis, and detoxification since ancient times [17]. And the general composition of dried lotus leaves is approximately 64% carbohydrates, 17% protein, 1% lipid, and 9% ash [13,14]. Among the mineral components, calcium content is about 2%, which is more than 20 times more than green tea [18]. In addition, it contains alkaloid components (roemerine, nuciferin, armepavine, N-nornuciferine, pronuciferine, etc.) that have analgesic and sedative effects, as well as tartaric acid, citric acid, malic acid, succinic acid, and tannin [19]. According to previous studies, the antioxidant effect of solvent extracts was verified through a study using lotus leaves, and a certain fraction of ethyl acetate obtained better results than commercially available antioxidants, and it was proven to have a better antibacterial effect than benzoic acid against some food poisoning bacteria [20,21]. It was reported that regular intake of lotus leaf powder regulated serum cholesterol and neutral lipid levels and promoted lipid metabolism by feeding it to rats [19]. In general, Bio FIB hamsters are highly susceptible to hyperlipidemia. For this reason, lotus leaves were added to the feed of Bio FIB hamsters and fed to them, and as a result, it was found that lotus leaves had the activity of suppressing hyperlipidemia [22].

Whey is the liquid portion obtained when separating the formed curds after coagulating milk with clotting enzyme or acid to produce cheese or casein used in food and industrial products [23]. Therefore, whey is opaque and yellow-green, has a solid content of 6.0%-6.5%, a biological oxygen demand (BOD) of over 32,000, and is classified into sweet whey, medium whey, and acid whey depending on pH, acidity, etc. [23]. Gene-

rally, sweet whey refers to acidity of 0.1%–0.2% and pH 5.8–6.6, medium whey refers to acidity of 0.2%–0.4% and pH 5.0–5.8, and acid whey refers to acidity of 0.4% or more and pH 5.0 or less [24]. Whey protein, which accounts for approximately 18% of milk protein, contains all types of amino acids essential for humans in various amounts and appropriate ratios. It is also in a form that is easily digestible and completely bioavailable [23]. Depending on the protein content, whey is divided into whey protein concentrate (WPC) and whey protein isolate (WPI). Whey protein is separated from whey and highly concentrated to between 34% and 80% is called WPC, and the most common manufacturing methods are ultrafiltration, ion exchange, and gel filtration [23,24]. WPI is made by processing whey as a raw material using CM-cellulose adsorption and then manufacturing it using ultrafiltration, and has a protein content of over 90% [23,25]. Whey is a very economical raw material that has various functions in processed foods and is rich in nutrients. Whey products containing lactose improve color and flavor, increase hygroscopicity, and improve food properties such as emulsification, availability, foaming, and dispersibility. As the cheese industry develops, the production of whey is increasing worldwide. And it is recognized as an important substitute for skim milk powder, so many studies have been conducted on the functionality of foods containing whey [26]. For example, when whey protein was added to rat feed, it was confirmed that whey protein could control cholesterol levels depending on the fat content of the feed. Based on these results, health supplements containing whey protein were developed to reduce cholesterol [27]. It has been reported that whey protein is added to various foods to improve flavor, color, nutrition, and texture, maintain quality, soften food, and increase the yield of processed cheese [26,27]. The excellent digestibility of whey protein and the fact that it contains various amino acids evenly are used in sports drinks [27]. Also the fat-soluble vitamin binding ability of β-lactoglobulin, which is abundant in whey protein, is used as a fat substitute in fat-free or low-fat foods [27].

Therefore, this study was conducted to manufacture regular soft ice cream (control), soft ice cream with lotus leaf extract, and soft ice cream with WPC-35 to provide basic data for the development of various functional soft ice creams as well as commercial feasibility.

Materials and Methods

1. Materials

The cream and skim milk powder used for making ice cream were purchased from Maeil (Korea) and Seoul Milk (Korea), respectively. Whey powder and WPC-35 were products of Samik Dairy Processing Company. Nutritional components of WPC-35 were 34.95 g of protein, 52 g of carbohydrate as lactose, 3.7 g of fat, 377 Kcal of calories per 100 g. And The lotus leaf powder used in this study was purchased from Muan, Jeollanam-do.

2. Manufacturing of functional soft ice cream

1) Manufacturing of lotus leaf extract

Five hundred grams (500 g) of lotus leaf powder was soaked in approximately twice the amount of 99% ethanol for one day, filtered through a qualitative filter paper (Whatman #1, UK), supplemented with ethanol, and soaked again for one day. After filtering once more the next day, it was concentrated using a rotatory evaporator (N-1000, EYELA, Japan), and then freeze-dried to manufacture lotus leaf extract powder.

2) Manufacturing of control soft ice cream, functional soft ice cream with lotus leaf extract and WPC-35

The detailed process for manufacturing three different types of soft ice cream in this study is shown in Fig. 1. First, three different soft ice cream mixes are prepared to produce soft ice cream according to Fig. 1. Hence, each mix is homogenized for 5 minutes using a homogenizer, and then the soft ice cream is produced using by the ice cream maker (SSI-141TG, Sea E&C, Korea).

3. Measurement of moisture, ash, lactose, and protein

The moisture, ash, lactose, and protein of the different types of soft ice cream manufactured in this study were measured according to the method of AOAC [28].

4. Measurement of antioxidant activity (AOA) by 1,1-diphenyl-2-picrylhydrazyl (DPPH) method

According to the method of Blois [29], the electron donating ability was measured using the reducing power of the extract as the electron donating effect to DPPH (Sigma-

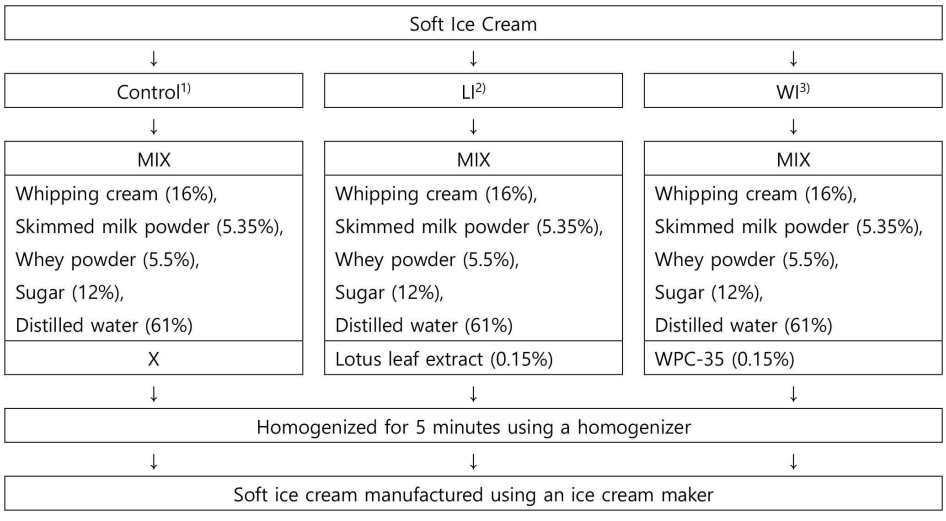

Fig. 1. Three different types of soft ice cream manufactured in this study. [1] Control, ice cream without lotus leaf extract and WPC-35, [2] LI, ice cream with lotus leaf extract, [3] WI, ice cream with WPC-35. WPC, whey protein concentrate.

Aldrich, USA). Twice the amount of methanol was added to 10 g of each of the control group, soft ice cream with lotus leaf extract, and soft ice cream with WPC-35, and mixed for 10 minutes. Then, centrifugation was performed at 1,538×g for 15 m using a centrifuge and the supernatant was collected. 0.8 mL of 4×10^{-4} M DPPH solution was added to each 0.2 mL of this extract, and the mixture was shaken with a vortex for 10 seconds. After 10 minutes, the absorbance was measured at 525 nm using a spectrophotometer (UV-1650PC, Shimadzu, Japan). The antioxidant activity (AOA) was expressed as a percentage by the formula.

5. Emulsifying activity (EA)

Emulsifying activity was measured according to the method of Peace & Kinsella [30]. Two grams (2 g) of freeze-dried powder (no additives, soft ice cream with lotus leaf extract, and soft ice cream with WPC-35) was added to 100 mL of water, mixed for 5 minutes, and adjusted to pH 7.0. One point five milliliter (1.5 mL) of this solution was mixed with 0.5 mL of canola oil, and the vortexed emulsion was placed in the cuvette of a spectrophotometer (UV-1650PC, Shimadzu), and the absorbance was measured at a wavelength of 500 nm, and analyzed by the following formula.

6. Sensory evaluation

The sensory evaluation was conducted on 10 experts majoring in animal food processing. After the evaluation committee members were educated on the test method and evaluation characteristics, the sensory evaluation was conducted. After manufacturing the three different types of soft ice creams manufactured in this study, they were frozen in a -22℃ freezer for 3 hours. Then, the test was conducted after about 30 minutes at room temperature. In order to find out the sensory differences between the non-additive, lotus leaf extract, and WPC-35, six items were evaluated such as color, taste, aroma, texture, sweetness, and overall preference. Each item was evaluated on a 5-point scale (1: very bad, 5: very good).

7. Statistical analysis

The data obtained in this study were statistically analyzed using GraphPad Prism 5 (GraphPad Softward, USA). "$p<0.05$" was indicated when there was a statistically significant difference.

Results and Discussion

The various results obtained in this study are presented in detail in the following Figs. Fig. 2 shows moisture, ash, lactose, and protein, Fig. 3 presents AOA and EA, and then Fig. 4 exhibits sensory evaluation, respectively.

1. Moisture

The moisture content of soft ice cream manufactured by adding lotus leaf extract and

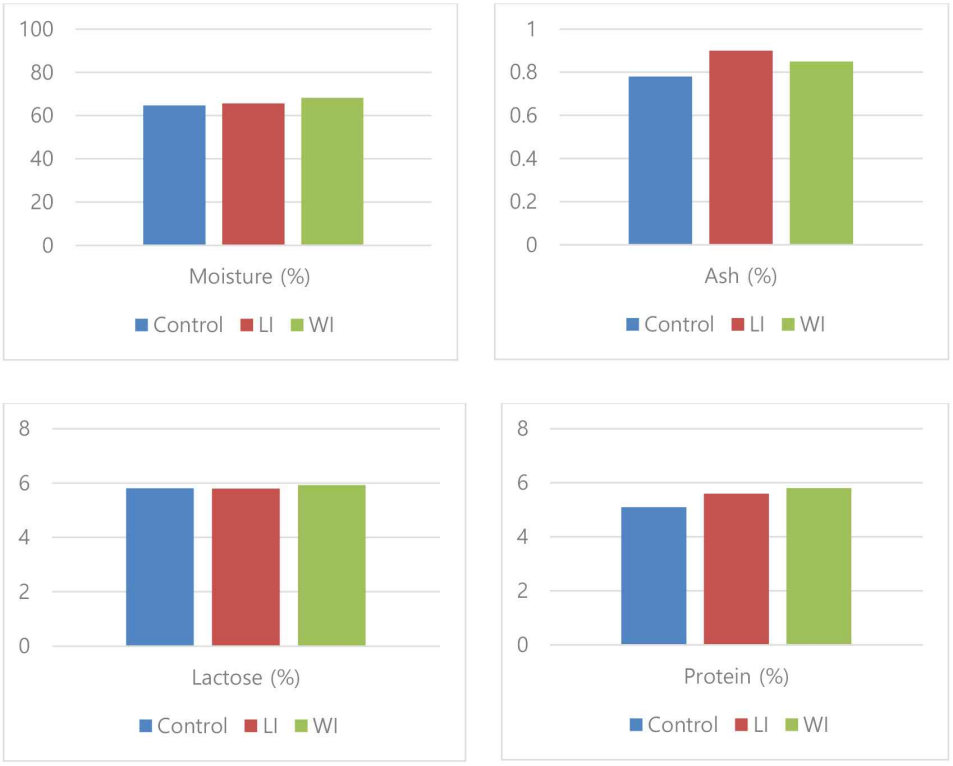

Fig. 2. General components of moisture, ash, lactose, and protein obtained from three different types of soft ice cream. Control: ice cream without lotus leaf extract and WPC-35. LI, ice cream with lotus leaf extract; WI, ice cream with WPC-35; WPC, whey protein concentrate.

WPC-35 is as shown in Fig. 2. As shown in Fig. 2, the moisture content of soft ice cream with lotus leaf extract was 65.6%, which was slightly lower than that of the control group (67.7%). Lotus leaf extract was used in this study, but several studies using lotus leaf powder reported that, unlike this study, moisture content significantly increased depending on the addition amount of lotus leaf powder [31,32]. This is thought to be due to the difference in the properties of lotus leaf extract and lotus leaf powder.

2. Ash content

The results of measuring the ash content of soft ice cream made by adding lotus leaf extract and WPC-35 are shown in Fig. 2. As shown in Fig. 2, the ash content of soft ice cream with lotus leaf extract was higher than that of the control group. According to a paper analyzing the general properties of lotus leaves, the calcium content was 2,208 mg per 100 g of dried lotus leaf powder, which was approximately 20 times higher than that of green tea (90 mg), and the ash content ratio was relatively high compared to the general properties of green tea [18]. It was reported that the contents of K, Ca, Na, and Fe in lotus leaf tea were higher than those in green tea [14,18]. Therefore, it is thought that the high ash content of soft ice cream with lotus leaf extract is due to the high ash content of lotus leaf extract.

3. Lactose

The lactose content of ice cream manufactured by adding lotus leaf extract and WPC-35 was as shown in Fig. 2. As shown in Fig. 2, the lactose content of soft ice cream with WPC-35 was relatively high. This is thought to be because the lactose content of WPC-35 is high at 52%. Lactose is a carbon dioxide that accounts for about 20% of carbohydrates in ice cream and 1/3 of the solid content in milk. Lactose is broken down into glucose by the action of a specific enzyme in the digestive organs and is ultimately converted into carbon dioxide. During this reaction, energy is generated and used as an energy source, and the excess sugar becomes fat and accumulates in the body. In addition, it has a low solubility and is slow to be absorbed in the body, so it stays in the intestines for a long time and acts to inhibit abnormal fermentation by producing lactic acid and causing acidic fermentation, and it acidifies the intestines, which helps bone formation by improving the absorption of calcium and the use of phosphorus by minerals [14,18]. Additional amounts of lactose in food are beneficial for calcium absorption, and ice cream rich in lactose helps maximize calcium digestion and absorption required by growing children and some adults [33]. Therefore, soft ice cream with WPC-35 is considered to be valuable as a snack for children and adult women for whom calcium intake is important.

4. Protein

The results of measuring the protein content of soft ice creams manufactured by adding lotus leaf extract and WPC-35 are shown in Fig. 2. The protein content of soft ice cream with WPC-35 was the highest, followed by soft ice cream with lotus leaf extract and the control group. It is thought that the high protein content of soft ice cream with WPC-35 is due to the high protein content of WPC. Nutritional properties from abundant protein help to health promotion. The biological value of whey protein is higher than that of proteins in high-quality foods such as eggs, beef, soybeans, and so on [27]. The main proteins contained in whey are β-lactoglobulin (48%), α-lactalbumin (19%), bovine serum albumin (8%), immunoglobulin (8%), lactoferrin, transferrin, and minerals [34]. Recently, many studies have been conducted on the health-promoting functionality of whey protein, and it has been reported that it stimulates the immune system, delays the development of chemically induced cancer, strengthens bones by increasing the growth and proliferation of osteoblasts, lowers LDL cholesterol, and so on [35,36]. Since a lot of new muscle and bone growth occurs in childhood, sufficient supply of calories, animal protein, and calcium is important. In addition, the protein requirement per body weight of the elderly is the same as that of young adults, and insufficient protein intake could cause muscle mass loss, decreased immune function, and delayed wound healing, so it is important to consume high-quality protein along with proper nutrition. Whey protein is not only easy to digest and absorb, but also contains a variety of amino acids, and in particular, it contains sufficient amounts of tryptophan, lysine, methionine, and isoleucine, amino acids in muscle tissue that are often lacking in foods [37]. Therefore, it is expected that soft ice cream with WPC-35

will be suitable as a dessert for children or the elderly who need protein-enhanced food. It is thought that the increase in crude protein content by adding lotus leaf extract is due to nitrogen compounds derived from lotus leaves.

5. Antioxidant activity (AOA) by 1,1-diphenyl-2-picrylhydrazyl (DPPH) method

The results of measuring the electron donating ability by DPPH radical are as shown in Fig. 3, and there was a significant difference depending on the additive ($p<0.05$). Compared to other soft ice creams, soft ice cream with lotus leaf extract had the highest AOA. It is thought that this is because it contains a large amount of flavonoids such as kaempferol, quercetin, and iso-quercetin, which are known as antioxidants among the various physiologically active substances contained in lotus leaves, as well as various polyphenol compounds such as tannic acid, oligomeric procyanidine, etc. [20,22]. Soft Ice cream with WPC-35 showed higher AOA than the control group, and this is supported by studies that milk contains antioxidant components. Whey protein is rich in cysteine and methionine, which are components of glutathione, and these sulfur-containing amino acids are said to maintain the body's antioxidant power and stabilize DNA during cell division [37]. It has been reported that enzymes such as superoxide dismutase and glutathione peroxidase contained in milk and non-enzymatic factors such as lactoferrin, ascorbic acid, tocopherol, and carotenoids have antioxidant effects [38]. The antioxidant function of food is not to remove or absorb oxygen, but to react with free radicals to minimize the loss of specific vitamins and essential amino acids, or to delay or prevent rancidity of oil products. Therefore, adding lotus leaf extract or WPC to ice cream, which has a relatively high fat content, is thought to be helpful in the effective intake of nutrients in milk and stably maintaining product quality. DPPH is a relatively stable free radical, and it measures AOA by utilizing the principle that the dark purple color is discolored when reduced by ascorbic acid, tocopherol, polyhydroxy aromatic compounds, and aromatic amines. Although AOA cannot be generally explained by electron donating ability, it is known that antioxidant substances in extracts have an important effect in terms of electron donating ability, which is the

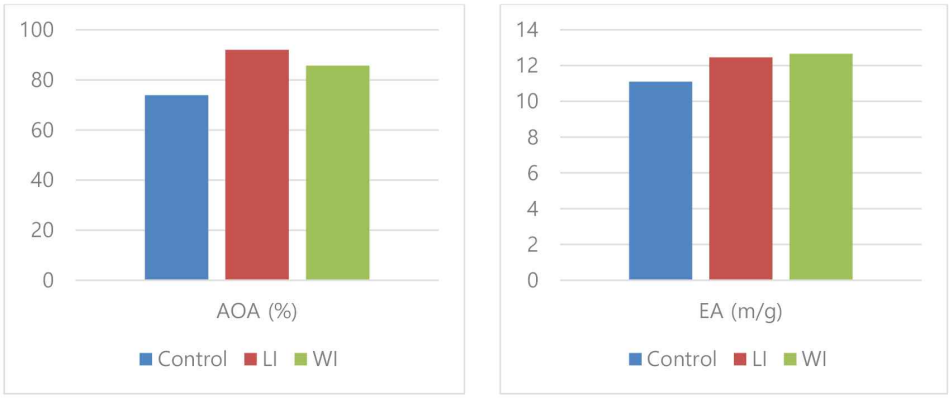

Fig. 3. The value of antioxidant activity (AOA) and emulsification activity (EA) obtained from three different types of soft ice cream. Control: ice cream without lotus leaf extract and WPC-35. LI, ice cream with lotus leaf extract; WI, ice cream with WPC-35; WPC, whey protein concentrate.

ability to donate electrons to radicals generated during the autoxidation process of oils and fats [29]. Therefore, this DPPH method is widely used because it can simply measure the AOA of plant extracts and is highly correlated with the actual AOA [39].

6. Emulsification activity (EA)

The results of measuring the emulsification activity, which indicates the degree to which water and oil are emulsified, are shown in Fig. 3. As shown in Fig. 3, the emulsification activity of soft ice cream with WPC-35 was the highest, followed by soft ice cream with lotus leaf extract, and the control group. Milk and dairy products contain natural emulsifiers and stabilizers (milk proteins, milk fat, lecithin, phosphates, citrate), and are stabilized by the effects of these natural substances during mixing and processing of raw materials [40]. Whey protein has both hydrophilic and hydrophobic parts, so it has the property of emulsifying fat and water well. It is thought that the emulsification activity of soft ice cream with WPC-35 was the highest due to this characteristic of whey protein. Among the various whey products produced in the United States, WPC-50 is widely used in the manufacture of dairy products, snacks, bakery products, sauces and dressings because of its advantages of fat absorption and emulsifying ability, and WPC-60 is used in the manufacture of low-fat dairy products, confectionery, and bakery because of its fat absorption and emulsifying ability [27]. In addition, WPC-75 has excellent viscosity and emulsifying ability, so it is added to the manufacture of processed fish and meat products and is utilized in the manufacture of nutritional foods, diet foods, and infant formula [27]. Ice cream mix is composed of substances existing in the true solvent (sugar, salt), colloidal suspensions (casein, stabilizers, insoluble sweetener solids, and some of the calcium and magnesium phosphates), and coarsely dispersed fat globules in the form of colloidal complexes. This emulsion has the property of resisting forces such as freezing, stirring, and concentration, and during the ice cream manufacturing process, the continuous phases change into a thick syrup form, and the dispersed phase is composed of bubbles, ice crystals, fat globules, casein micelles, and hydrocolloids [41]. These properties make ice cream have a fine structure in which three types of tissues are mixed, namely, solid phase, liquid phase, and gaseous phase, and bubbles of around 150 μm are dispersed in the liquid phase including ice crystals of about 50 μm, and solid phases such as fat globules, lactose crystals, and insoluble salts of 2 μm or less are dispersed in the liquid phase [42]. Therefore, the higher the EA in ice cream, the softer it becomes and the firmer the texture, so it plays an important role in determining the texture and shape of ice cream. Currently, the ice cream industry uses emulsifiers along with stabilizers to produce ice cream with a soft texture and a hard shape, and mainly uses monoglycerides and diglycerides extracted from fatty acids. However, since food additives are synthetic chemical compounds, it has been pointed out that if consumed in large quantities over a long period of time, they can accumulate in the body and cause harm to the human body [43]. In a recent survey on consumer awareness of food additives due to the influence of wellness, it can be seen that the EA of ice cream with WPC is high, considering that the desire to purchase products containing food additives is low.

7. Sensory evaluation

Fig. 4 presents the sensory evaluation results for preference for the three different types of soft ice cream (no addition as control, addition of lotus leaf extract, addition of WPC-35, respectively) manufactured in this study in detail.

The color score was the highest for the soft ice cream with lotus leaf extract. This is because the green color of the lotus leaf extract gives a visual freshness, and this can be highlighted as the greatest advantage if the soft ice cream with lotus leaf extract is developed as a product in the future. In addition, while the green tea ice cream sold on the market has a dark and cloudy green color, the soft ice cream with lotus leaf extract manufactured in this study has a clear and light green color and does not require the addition of synthetic pigments, so it is thought to be a more health-oriented product.

Taste was 2.7 points for the control group, 3.9 points for the soft ice cream with lotus leaf, and 3.1 points for the soft ice cream with WPC-35. The soft ice cream with lotus leaf extract received the highest score. The reason for this is that the bitter taste of the lotus leaf affects the refreshing taste of the milk's unique bitterness and sweetness in the ice cream.

In terms of flavor, the soft ice cream with lotus leaf extract received a significantly high score. This shows that the fragrant and subtle green flavor of the lotus leaf has a high preference in ice cream with relatively high milk fat, and the flavor is thought to affect the overall preference. This result is consistent with a study in which the preference increased as the addition amount of lotus leaf powder increased. On the other hand, in a study on the production of mulberry leaf ice cream, it was reported that the unique raw flavor of mulberry leaves not only caused people to avoid mulberry

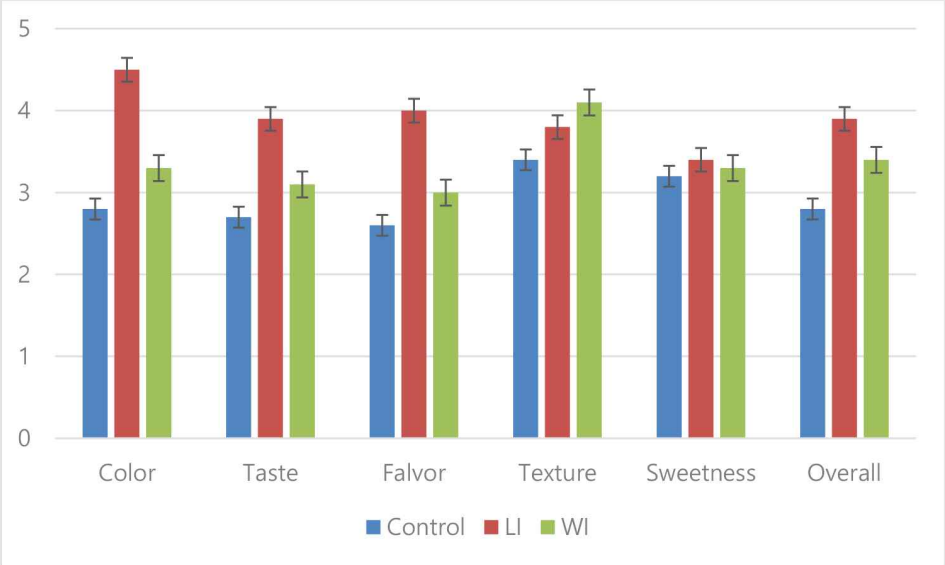

Fig. 4. The level of sensory evaluation obtained from three different types of soft ice cream Control: ice cream without lotus leaf extract and WPC-35. LI, ice cream with lotus leaf extract; WI, ice cream with WPC-35; WPC, whey protein concentrate.

leaf ice cream, but also caused prejudice against ice cream, thereby lowering the preference of ice cream and indirectly affecting the taste and quality. In the case of mulberry sorbet ice cream, there was concern that the unique flavor of mulberry would act as an unpleasant flavor when developing the product, but it was reported that it did not affect the preference. The soft ice cream with WPC-35 received a higher score than the control group, which is thought to be due to the mild flavor of whey protein. In its pure form, whey protein has a very mild flavor, and depending on the application method, it has the characteristic of highlighting the existing flavor well or adding its own flavor.

The texture of ice cream is determined by the size of ice crystals, the size and distribution of bubbles, and the size of unfrozen particles in the ice cream. Texture was the highest in soft ice cream with WPC-35, which is thought to be due to the characteristic of making very even foam when whey is added to the product, which gives a soft texture. Foaming ability is one of the important properties in food, and foaming characteristics play a critical role in the production of whipped toppings, ice cream, ice cream, and frozen yogurt. There was no significant difference in sweetness, but the soft ice cream with lotus leaf extract was evaluated as slightly sweeter despite the bitterness of the lotus leaf extract, which is thought to be because the bitterness of the lotus leaf extract was felt at first taste, followed by the sweetness.

The overall preference was in the order of soft ice cream with lotus leaf extract, soft ice cream with WPC-35, and the control group, and it was found that color, flavor, and texture affected the overall preference. In the case of soft ice cream with WPC-35, the score for flavor was higher than that of the control group, but it is thought that the rough flavor unique to skimmed milk powder and dairy products affected the taste and overall preference. This is consistent with the results of a previous study that reported that, regardless of the form of quality, flavor had the greatest influence on the overall quality in terms of the correlation between the appearance, flavor, and texture of ice cream and the overall quality, whereas surprisingly, texture showed almost no correlation [44]. Therefore, it is expected that adding flavoring to soft ice cream with WPC-35 would result in higher preference in taste and aroma.

Sensory evaluation measures, analyzes, and interprets reactions detected by the five senses of humans, namely, sight, smell, taste, touch, and hearing. First of all, after measuring the characteristics of food or substances, it is necessary to understand how these characteristics affect consumer preferences. In other words, this process can play an important role in developing products that consumers need.

8. Comparison of soft ice cream with lotus leaf extract and ice cream with whey protein concentrate (WPC)-35

The analysis results of soft ice cream with lotus leaf extract and soft ice cream with WPC-35 are as shown in Figs. 2-4. Lactose was higher in soft ice cream with WPC-35 at 5.93% than in soft ice cream with lotus leaf extract, which is thought to be due to the high lactose content in WPC. Moisture content was 68.2% in soft ice cream with

WPC-35 and 65.6% in soft ice cream with lotus leaf extract, which was higher in soft ice cream with WPC-35, and there was no significant difference in ash content between soft ice cream with lotus leaf extract and soft ice cream with WPC-35. Protein content was higher in soft ice cream with WPC-35 than in soft ice cream with lotus leaf extract. The EA was slightly higher in soft ice cream with WPC-35. The electron donating ability by the DPPH method was 92% for the soft ice cream with lotus leaf extract and 85.7% for the soft ice cream with WPC-35, showing a higher AOA in the soft ice cream with lotus leaf extract. The overall preference for the sensory evaluation was 3.9 points for the soft ice cream with lotus leaf extract, which was higher than that for the soft ice cream with WPC-35. Although functional ice creams tend to have low preference, it is thought that the soft ice cream with lotus leaf extract scored high in color and flavor, which increased the overall preference.

Conclusion

This study aimed to meet the consumer demand for health functional foods using natural ingredients that are beneficial to health, which are currently established as a major food, by manufacturing soft ice cream with lotus leaf extract and WPC-35. *N. nucifera* has been used as a folk remedy as well as food. Recently, the antioxidant and antibacterial effects of lotus leaf extract have been proven, and it has been reported that regular consumption of lotus leaf has cholesterol-regulating effects and hyperlipidemia-suppressing effects. Whey is a byproduct produced during cheese manufacturing. It improves color and flavor and food properties such as emulsification, availability, foaming, and dispersibility, and has been used in various ways in the food, feed, pharmaceutical, and cosmetics industries. Recently, studies on the nutritional and biological functions of whey protein have reported that it is effective in cholesterol regulation, immune enhancement, and bone strengthening. Hence, based on the conclusions obtained from this study, additional research should be conducted to clarify functionality and improve sensory evaluation in order to commercially launch the product in the future.

Conflict of Interest

The authors declare no potential conflict of interest.

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