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ARTICLE

Sensory Profiles of Dairy Products Supplemented with *Hibiscus sabdariffa* Linnaeus (Roselle) Powder: A Preliminary Study

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Abstract

The objective of this study was to evaluate the sensory profiles of market milk, yogurt, and kefir, supplemented with the powder of *Hibiscus sabdariffa Linnaeus* (Roselle) in 1% increments, ranging from 0% (control) to 4%. In this study, there was no statistically significant difference in titratable acidity and pH between the treated groups and the control group. All samples were evaluated in five categories by thirteen appraisers. Compared to the control group, the best sensory profiles were observed in the market milk sample supplemented with 1.0% of *Hibiscus sabdariffa Linnaeus* (Roselle) powder, in the yogurt samples supplemented with 2.0% and 3.0% of *Hibiscus sabdariffa Linnaeus* (Roselle) powder, and in the Kefir sample supplemented with 3% of *Hibiscus sabdariffa Linnaeus* (Roselle) powder. According to statistical analysis of the sensory profiles obtained in this study, there was a statistical difference in the taste, flavor, color, and overall acceptability of market milk; in the taste, color, texture, and overall acceptability of yogurt; and in the taste, color, and overall acceptability of Kefir, between the treated groups and the control group ($p<0.05$). In the future, when *Hibiscus sabdariffa Linnaeus* (Roselle) powder is used as a food additive for dairy products, studies on improvement of biofunctionality, as well as of sensory profiles in dairy products must be carried out.

Keywords

Hibiscus sabdariffa Linnaeus (Roselle) powder, sensory profiles, dairy food, Kefir

Introduction

In general, *Hibiscus* included over 300 species of annual or perennial herbs, shrubs or trees [1, 2]. *Hibiscus sabdariffa* Linnaeus was recognized as Roselle and was an ideal crop for developing countries because it could be relatively easy to cultivate [1, 2]. Also *Hibiscus sabdariffa* Linnaeus (Roselle) could be used as food and fiber, and also cultivated as part of multi-cropping systems [1]. Until now, *Hibiscus sabdariffa* Linnaeus (Roselle) was used as a traditional foods or medicine depending on the region [1, 3]. For example, in Africa, India and Mexico, the infusions of the leaves or calyces of *Hibiscus sabdariffa* Linnaeus (Roselle) were used for having a good effect on cholerectic, diuretic, febrifuge, hypotension, and so on, and were traditionally used for stimulating the intestinal peristalsis and for decreasing the blood's viscosity [1-3]. In North Africa, the preparations of calyces of *Hibiscus sabdariffa* Linnaeus (Roselle) were used to treat coughs, genital problems, sore throats, and so on [1, 3, 4]. And in folk medicine of China, it was used to treat high blood pressure and liver disorders [1, 5]. Furthermore, the main components

related to the pharmacological effects of *Hibiscus sabdariffa* Linnaeus (Roselle) were anthocyanins, flavonoids, hibiscus acid, hydrooxycitric acid, organic acids, polysaccharides (carbohydrates, mucilage and pectin), volatile compounds, and so on [1, 3, 6]. The various biofunctional and pharmacological characteristics of *Hibiscus sabdariffa* Linnaeus (Roselle) was shown in Fig. 1 [1, 3]. Therefore, *Hibiscus sabdariffa* Linnaeus (Roselle) powder could be added directly to several dairy products because it could improves the sensory profiles and the human health through several bioactive components.

Subsequently, the ultimate objective of this study was to prepare market milk, yoghurt and Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) for upgrading the sensory profiles with having biofunctional properties.

Materials and Methods

1. The powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

The organic Roselle *Hibiscus* extract powder which was made up of 100% *Hibiscus sabdariffa* Linnaeus (Roselle) as the food-additive grade was grown in Poland (Lilly Super Food, Korea).

2. Production of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

According to the method [7], the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) was added to market milk (Seoul Dairy Co-op, Korea) in 1% increments, from 0% (control) to 4%, respectively,

3. Production of yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

According to the modified method [7], the powder of *Hibiscus sabdariffa* Linnaeus

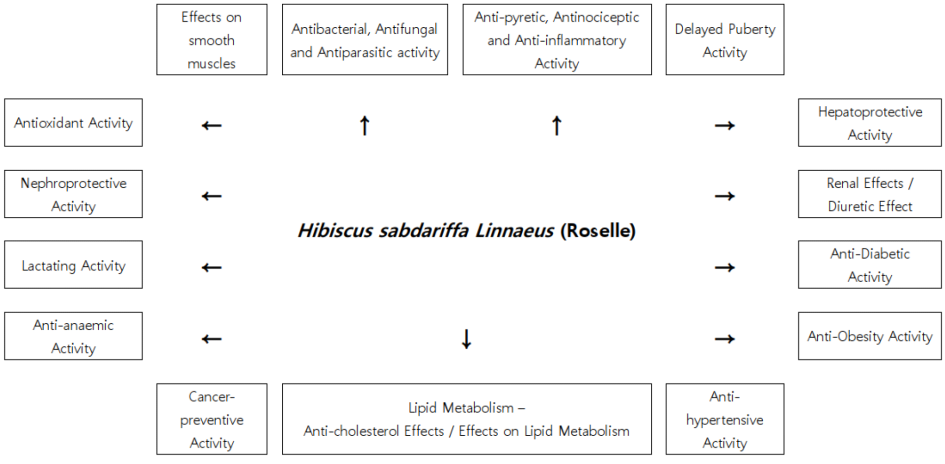

Fig. 1. The various biofunctional and pharmacological characteristics of *Hibiscus sabdariffa* Linnaeus (Roselle).

(Roselle) was added to yoghurt in 1% increments, from 0% (control) to 4%, respectively.

4. Production of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) powder

According to the modified method [7], the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) was added to Kefir in 1% increments, from 0% (control) to 4%, respectively.

5. The TA and pH of market milk, yogurt and Kefir with *Hibiscus sabdariffa* Linnaeus (Roselle) powder

According to method [8], the titratable acid (TA) and pH of market milk, yogurt and Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) was analyzed by titration with 0.1 N NaOH (Sigma-Aldrich Co., USA), and by the pH meter (Orion Star A211, USA), respectively.

6. The sensory profiles of market milk, yogurt and Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

Market milk, yogurt and Kefir added with powder of *Hibiscus sabdariffa* Linnaeus (Roselle) were manufactured and kept in fridge until they were analyzed. All 13 appraisers participated in this study, and then evaluated the sensory profiles for each sample. In this study, the samples were randomly tested in disposable paper cups (50 mL) at 10℃. The sensory profiles consisted of five different categories (Table 1).

7. Statistical data analysis

In this study, all results were taken from two separate experiments with duplicate assays. Using the statistical software of GraphPad Prism 5 (GraphPad Softward Inc., USA), results was analyzed. Also, all results were demonstrated as means±SD. There was a statistically significant difference between the groups (p<0.05).

Results and Discussion

1. The TA and pH of market milk, yogurt and Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

TA generally affected pH levels [8]. In this study, the pH and TA of market milk was about 6.65 and 0.15%, respectively. And the pH of yogurt and Kefir dropped to 4.35

Table 1. Five different categories of the sensory profiles and 5-point hedonic value

Category of sensory profiles	Five-point hedonic value
Overall acceptability	1 : Extremely poor
Texture	2 : Poor
Flavor	3 : Fair
Color	4 : Good
Taste	5 : Excellent

and 4.50, respectively, whereas the TA of yogurt and Kefir went up to 1.0% and 0.94, respectively (Data not shown).

The level of TA and pH of market milk, yogurt and Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) demonstrated similar to that of market milk, yogurt and Kefir without having the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) (Data not shown). Therefore, the TA and pH did not represent any statistical significant difference between treated group and control group conducted in this study. This study also showed a similar tendency to various previous studies [8-10].

2. The sensory profiles of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

The sensory profiles of market milk were evaluated by thirteen appraisers. Fig. 2 showed the summary of sensory profiles.

The powder of *Hibiscus sabdariffa* Linnaeus (Roselle) was added to market milk in 1% increments, from 0% (control) to 4%, respectively. The taste value of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.66 to 2.33, which were lower than 4.16 of control group (addition of 0%). The flavor value of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.66 to 3.16, which was lower than 4.16 of control group (addition of 0%). The color value of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 2.5 to 1.66, which was lower than 4.3 of control group (addition of 0%). The texture value of market milk added with the powder of *Hibiscus sabdariffa*

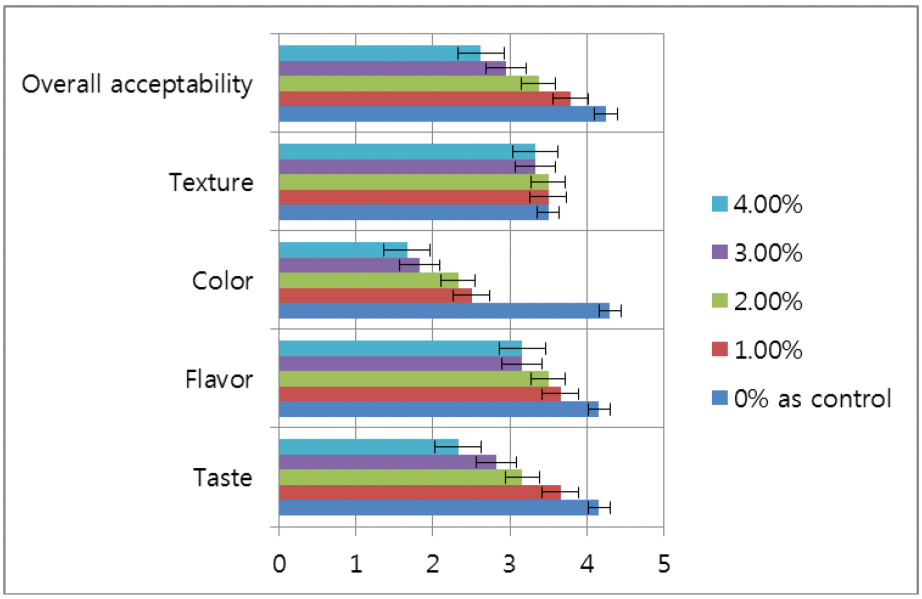

Fig. 2. The sensory profiles of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments, from 0% (control) to 4%, respectively.

Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.5 to 3.33, which was similar or lower than 3.5 of control group (addition of 0%). And the overall acceptability value of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.79 to 2.62, which was lower than 4.25 of control group (addition of 0%). According to statistical analysis on the sensory profiles of market milk, there was a statistically significant difference in taste, flavor, color, and overall acceptability between treated group and control group ($p<0.05$). Among the treated group, the market milk added with 1% of *Hibiscus sabdariffa* Linnaeus (Roselle) powder showed the best results compared with control group.

In a word, as the addition of *Hibiscus sabdariffa* Linnaeus (Roselle) powder increased, the category of taste, flavor, color, and overall acceptability tended to decrease except texture.

3. The sensory profiles of yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

The sensory profiles of yogurt were evaluated by thirteen appraisers. Fig. 3 showed the summary of sensory profiles.

The powder of *Hibiscus sabdariffa* Linnaeus (Roselle) was added to yogurt in 1% increments, from 0% (control) to 4%, respectively. The taste value of yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.66 to 3.33, which were lower than 3.83 of control group (addition of 0%). The flavor value of yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 4.0 to 3.5, which were higher or lower (or similar) than 3.66 of control group (addition of 0%). The color value of

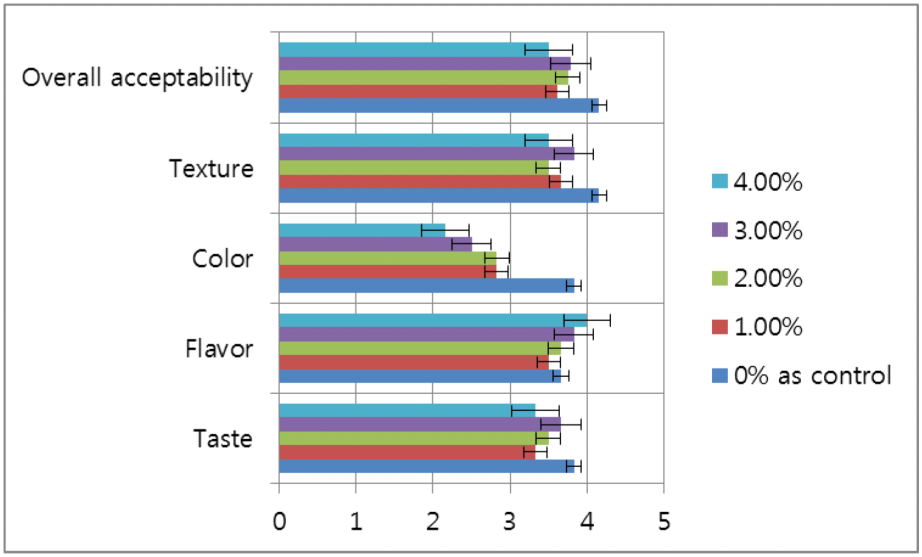

Fig. 3. The sensory profiles of yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments, from 0% (control) to 4%, respectively.

yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 2.83 to 2.16, which were lower than 3.83 of control group (addition of 0%). The texture value of yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.83 to 3.5, which were lower than 4.16 of control group (addition of 0%). And the overall acceptability value of yogurt added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.79 to 3.5, which were lower than 4.16 of control group (addition of 0%).

According to statistical analysis on the sensory profiles of yogurt, there was a statistically significant difference in taste, color, texture and overall acceptability between treated group and control group ($p<0.05$). Among the treated group, the yogurt added with 3.0% (and 2.0%) of *Hibiscus sabdariffa* Linnaeus (Roselle) powder showed the best results compared with control group.

In a word, as the addition of *Hibiscus sabdariffa* Linnaeus (Roselle) powder increased, the category of taste, color, texture and overall acceptability tended to decrease except flavor.

4. The sensory profiles of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle)

The sensory profiles of Kefir were evaluated by thirteen appraisers. Fig. 4 showed the summary of sensory profiles.

The powder of *Hibiscus sabdariffa* Linnaeus (Roselle) was added to Kefir in 1% increments, from 0% (control) to 4%, respectively. The taste value of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from

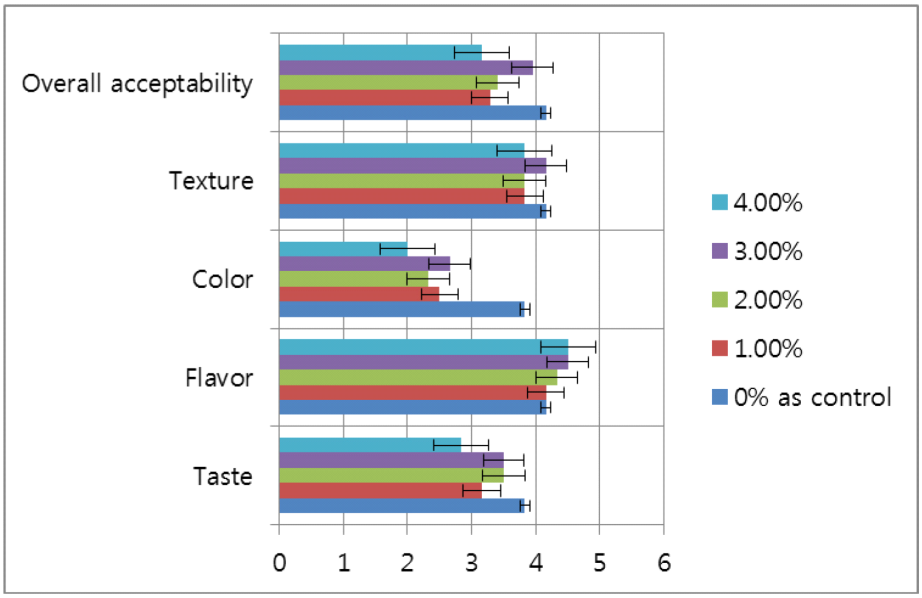

Fig. 4. The sensory profiles of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments, from 0% (control) to 4%, respectively.

3.5 to 2.83, which were lower than 3.84 of control group (addition of 0%). The flavor value of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 4.5 to 4.16, which were similar or lower (or similar) than 4.5 of control group (addition of 0%). The color value of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 2.66 to 2.0, which were lower than 3.84 of control group (addition of 0%). The texture value of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 4.16 to 3.83, which were lower than 4.17 of control group (addition of 0%). And the overall acceptability value of Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) was from 3.95 to 3.16, which were lower than 4.17 of control group (addition of 0%).

According to statistical analysis on the sensory profiles of Kefir, there was a statistically significant difference in taste, color and overall acceptability between treated group and control group ($p<0.05$). Among the treated group, the Kefir added with 3.0% of *Hibiscus sabdariffa* Linnaeus (Roselle) powder showed the best results compared with control group.

In a word, as the addition of *Hibiscus sabdariffa* Linnaeus (Roselle) powder increased, the category of taste, color, texture and overall acceptability tended to decrease except flavor.

Next, Fig. 5 showed the changes of color in market milk-, yoghurt-, and Kefir-added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%). In this study, yogurt and Kefir added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) had no red color change, but market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments (from 1.0% to 4.0%) changed from red to gray (Fig. 5). It may be thought

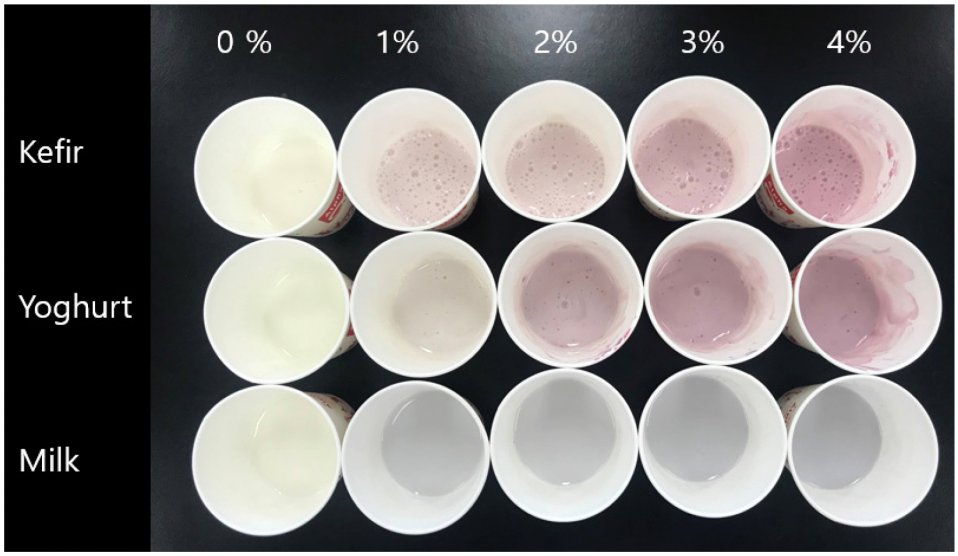

Fig. 5. The color changes of market milk, yoghurt and Kefir according to the addition of the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) in 1% increments, from 0% (control) to 4%, respectively.

that the color of market milk added with the powder of *Hibiscus sabdariffa* Linnaeus (Roselle) changed under the influence of pH. And it could be explained in more detail for the following reason. The colorful anthocyanins were known as the flavonoids group of phytochemicals, and also anthocyanins's molecules were susceptible to degradation. For example, the stability of colorful anthocyanins's molecules depended on light, metals, pH, phenolic acids, temperature, the presence of enzyme or other flavonoids, and so on [3]. However, more detailed research will have to be done.

Hibiscus sabdariffa Linnaeus (Roselle) was generally grown for its calyces and fibers, and also was divided into 3 types of genotypes such as dark red, green, and red [11, 12]. Among them, the genotype of red was the most common type used [12]. Especially, anthocyanins were a group of phenolic compounds and could be found in a variety range of fruits and flowers to demonstrate the reddish-purple color [11]. Furthermore, anthocyanins could be used for natural alternatives to replace the artificial synthetic color additives in the food industry [11]. Especially, the calyx of *Hibiscus sabdariffa* Linnaeus (Roselle) was known to contain the compounds responsible for the red color of this plant, which were delphinidin-3-glucoside, cyaniding-3-glucoside, delphinidin-3-sambubioside, cyaniding-3-sambubioside, and so on [13].

In conclusion, even though *Hibiscus sabdariffa* Linnaeus (Roselle) powder may be effective in improving human health according to previous studies [1-4, 11, 13], more future research on the availability of *Hibiscus sabdariffa* Linnaeus (Roselle) extracts as a natural color ingredients as well as the development of various biofunctioanl dairy products must be carried out.

Conflict of Interest

The authors declare no potential conflict of interest.

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