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ARTICLE

Organoleptic Characteristics of Dairy Products Supplemented with *Raphanus raphanistrum* subsp. *sativus* (radish) Powder: A Preliminary Study on Efficacy against Diabetes

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Abstract

Raphanus raphanistrum subsp. *sativus* (radish) powder contains several bioactive compounds and is widely used in the food industry. In this study, we examined the sensory attributes (taste, color, flavor, texture, and overall acceptability) of commercially available milk, yoghurt, and kefir containing different concentrations of *R. raphanistrum* subsp. *sativus* powder. The organoleptic characteristics of commercially available milk, yoghurt, and kefir was significantly different with respect to taste, flavor, color, texture, and overall acceptability in the treated group (1%, 2%. 3%. and 4%) compared to the control (0%; $p<0.05$). In addition, the scores of taste, flavor, color, texture, and overall acceptability decreased in proportion to the increase in amount of radish-powder in commercially available milk, yoghurt, and kefir. When 1% *R. raphanistrum* subsp. *sativus* powder was added to commercially available milk, yoghurt, and kefir, they showed good results in organoleptic characteristics compared to the control group. Therefore, our results could be used as the basis for estimating changes in organoleptic characteristics on supplementation of various dairy products with *R. raphanistrum* subsp. *sativus*.

Keywords

Raphanus raphanistrum subsp. *sativus* (radish), organoleptic characteristics, dairy products, diabetes

Introduction

In general, *Raphanus raphanistrum* subsp. *sativus* (radish) recognized as the root vegetable was used for the human diet all over the world [1]. Many people would like to eat untreated raw radishes as a crunchy vegetable, and some people of the Middle East tried to drink the juice of *Raphanus raphanistrum* subsp. *sativus* (radish) so as to take various health benefits [1] (Fig. 1). The skin color of *Raphanus raphanistrum* subsp. *sativus* (radish) were known to vary widely such as red, purple, black, yellow, and white through pink, and so on, but the inside color of *Raphanus raphanistrum* subsp. *sativus* (radish) was generally white [1]. Furthermore, the flavor, length and size of *Raphanus raphanistrum* subsp. *sativus* (radish) that could be eaten in each country were reported to be very diverse [1,2]. As it had been know, *Raphanus raphanistrum* subsp. *sativus* (radish) was typically composed of carbohydrates, dietary fibers, fat, fluoride, minerals

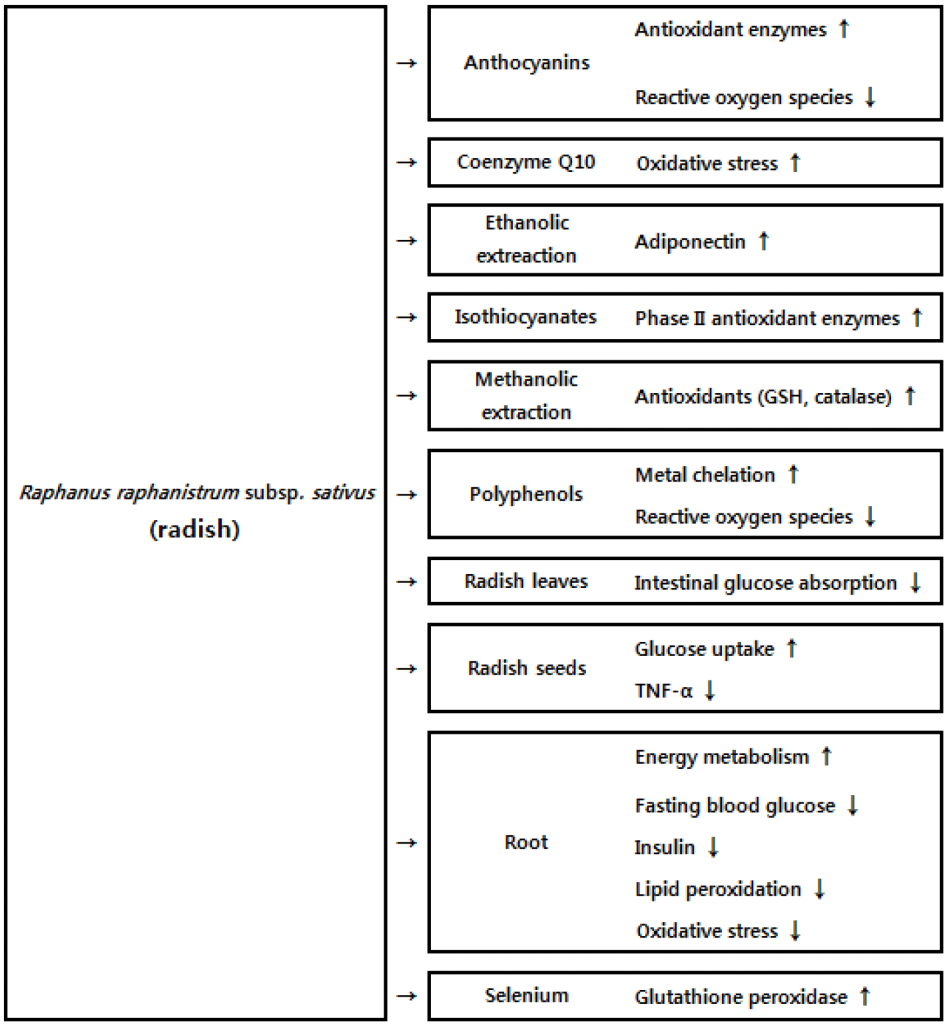

Fig. 1. Various effects of *Raphanus raphanistrum* subsp. *sativus*'s (radish) and its bioactive substances on type 2 diabteic conditions. Adapted from Banihani [1].

(calcium, iron, magnesium, manganese zinc, potassium, phosphorous, etc), protein, sugar, water-soluble vitamins (B_1, B_2, B_3, B_5, B_6, B_9, and C) [3].

Recently, a variety of studies have revealed the efficacy of *Raphanus raphanistrum* subsp. *sativus* (radish) in improving human health. Until now, the major bioactive substances found in *Raphanus raphanistrum* subsp. *sativus* (radish) were (1) glucosinolates such as glucoerucin, glucoraphanin, glucoraphasatin, glucobrassicin, 4-hydroxyglucobrassicin, 4-methioxyglucobrassicin and neoglucobrassicin, and (2) isothiocyanates such as indole-3-carbinol, sulforaphane and sulforaphene [4-6]. Among the various bioactive substances, isothiocyanates was a particularly important bioactive substance of *Raphanus raphanistrum* subsp. *sativus* (radish) [6]. The isothiocyanates were breakdown products resulting from the enzymatic hydrolysis of glucosinolates by myrosinase. Since *Raphanus raphanistrum* subsp. *sativus* (radish) had myrosinase, and also the enzymatic activity of myrosinase was present in the intestinal microflora of the human colon [1,6,7].

Now, the number of diabetic people was dramatically uprising every year. Hence, the diabetes was recognized as a very difficult problem to solve medically, since it was a serious illness characterized by uncontrolled glucose hemostasis [8]. Furthermore, the diabetes was one of the top leading causes of death in humans [9]. Therefore, lots of researches were concentrated to find out the effective oral remedy and (or) home treatment to handle the diabetes were still direly needed [1]. The WHO-affiliated committee of diabetic experts strongly suggested the need to investigating the antidiabetic substance derived from the origin of plants, although there were unwanted side effects of it which were not fully known scientifically [1,10,11]. Until now, gastrointestinal irritation, nausea, and thyrotropin suppression were known as the adverse effect of synthetic hypoglycemic drugs [10,11].

Consequently, the final goal of this study was to produce market milk, yoghurt and Kefir added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder for helping the preventive diabetes and also improving organoleptic characteristics. In this experiment, among various physicochemical characteristics of dairy products, organoleptic characteristics of market milk, yoghurt and Kefir added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder were analyzed.

Materials and Methods

1. *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

The power type of *Raphanus raphanistrum* subsp. *sativus*'s (radish) was produced in Korean and bought form Heungyildang Food of Korea, and also was the food additive grade used in this study.

2. Manufacture of market milk added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

The powder of *Raphanus raphanistrum* subsp. *sativus*'s (radish) was added to market milk (Seoul Dairy Co-op, Korea) at concentrations of 0% (control), 1.0%, 2.0%, 3.0%, and 4.0%, respectively, and then mixed thoroughly). Then, the market milk with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder was kept at 4℃.

3. Manufacture of yoghurt added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

According to the instruction given by Kim et al. [12], *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder was added to yoghurt premix at concentrations of 0% (control), 0.5%, 2.0%, 3.0%, and 4.0%, and then mixed thoroughly. In this study, a ready-mixed starter culture (Lyofast YAB 450AB, Sacco srl., Codaragok, Italy) consisted of *Streptococcus thermophiles, Lactobacillus delbrueckii* ssp. *bulgaricus, Lactobacillus acidophilus,* and *Bifidobacterium animalis* ssp. *lactis* was artificially inoculated and then fermented at 42℃ for at least 5 hours. The yoghurt was kept at around 4℃ for one day (over 18 hours).

4. Manufacture of Kefir added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

According to the instruction given by Kim et al. [13], Kefir was manufacture by Kefir grains obtained from KU Center for Food Safety, College of Veterinary Medicine, Konkuk University in Seoul, Korea. Then Kefir samples were added with different concentration of *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%). The final Kefir products were cooled at 4℃ and then stored in a refrigerator (Fig. 2).

5. Organoleptic characteristics of market milk, yoghurt, and Kefir added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

The organoleptic characteristics were analyzed by 12 trained panelists between 20 and 50 years of age who gave written informed consent after explanation of risk-benefits of participation prior to the study. The samples was randomly served in single-use plastic cups (10 mL) about 10℃, and all evaluators completed a test assessment form to compare five different organoleptic characteristics such as taste, flavor, color, texture and overall acceptability with the five-point hedonic scale (5 as excellent; 4 as good; 3 as fair; 2 as poor; and 1 as extremely poor).

6. Analysis of statistics

All data were showed as means±SD which were performed by two separate experiments with duplicate assays in this study, and statistical significance was considered at $p<0.05$ using GraphPad Prism 5.0 (GraphPad Softward Inc., San Diegeo, CA, USA).

Results and Discussion

1. Oganoleptic characteristics of market milk added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

The market milk was prepared with addition of *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder at concentrations of 0% (as control), 1.0%, 2.0%, 3.0%, and 4.0%, respectively, and the results were summarized in Fig. 3.

The scores of taste in market milk with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 3.33, 2.5, 2.33, and 2.16, respectively. The scores of color in market milk with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 3.0, 2.83, 2.33, and 2.0, respectively. The scores of flavor in market milk with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 3.83, 3.0, 2.5, and 1.83, respectively. The scores of texture in market milk with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 4.33, 4.0, 3.66, and 3.33, respectively. And the scores of overall acceptability in market milk with *Raphanus raphanistrum* subsp.

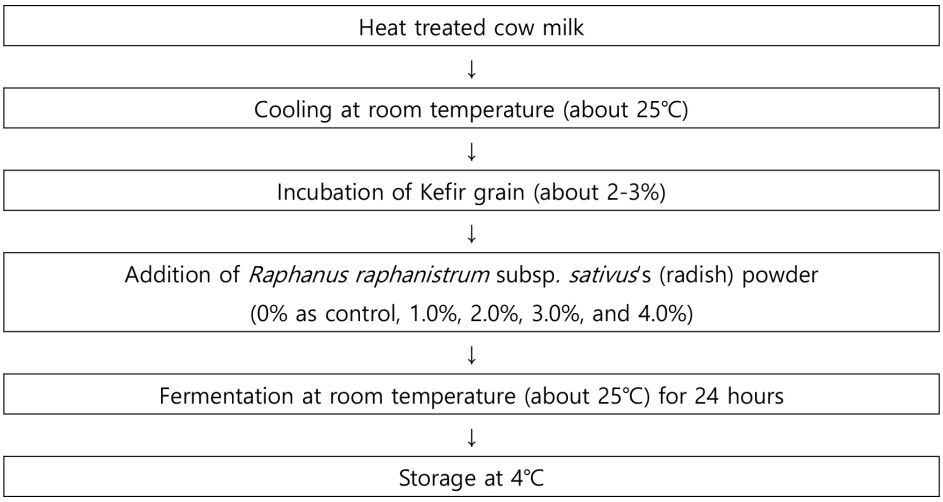

Fig. 2. Manufacture of Kefir added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%).

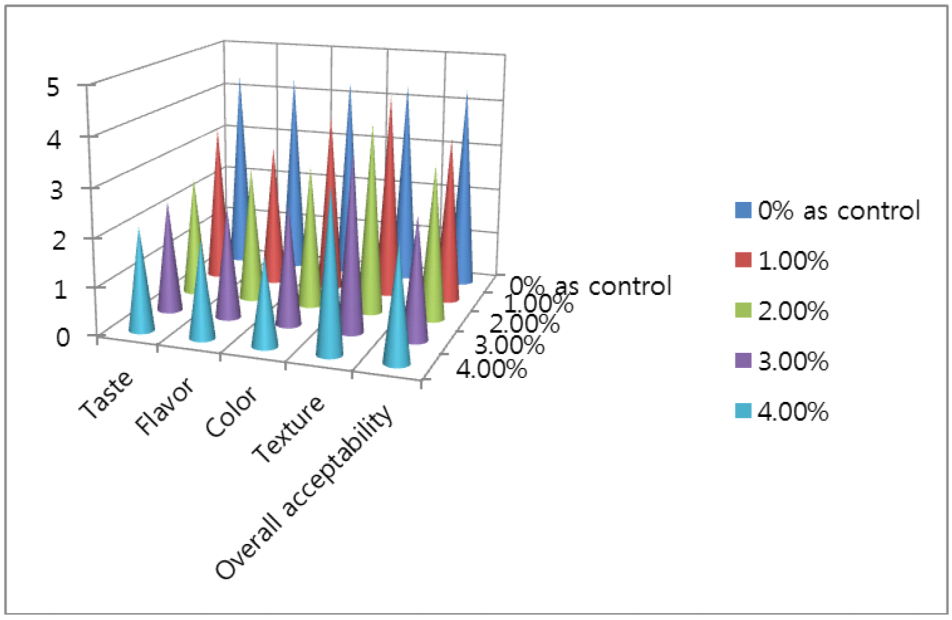

Fig. 3. Comparison of organoleptic characteristics of market milk added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%).

sativus's (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 3.5, 3.25, 2.54, and 2.37, respectively.

According to statistical analysis of the organoleptic characteristics in market milk, there was statistical difference in taste, flavor, color, texture and overall acceptability between treated group and control group (p<0.05). Consequently, the scores of taste, flavor, texture and overall acceptability were lower in *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder-containing market milk with 1.0%, 2.0%, 3.0%, and 4.0% than with the control group (0%).

2. Organoleptic characteristics of yoghurt added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

The yoghurt was prepared with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder at concentrations of 0% (as control), 1.0%, 2.0%, 3.0%, and 4.0%, respectively, and the results were summarized in Fig. 4.

The scores of taste in yoghurt with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 3.16, 2.83, 2.5, and 2.33, respectively. The scores of color in yoghurt with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.66, 3.66, 2.83, 2.5, and 1.83, respectively. The scores of flavor in yoghurt with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 3.66 2.5, 2.33, and 2.16, respectively. The scores of texture in yoghurt with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.16, 3.5, 3.0, 2.66, and 2.5, respectively. And the scores of overall acceptability scores in yoghurt with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.41, 3.75, 3.08, 2.75, and 2.62, respectively. Consequently, among the treated group compared with the control group (0%), the scores of taste, flavor, texture and overall acceptability were the same or lower in *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder-containing yoghurt with 1.0%, 2.0%, 3.0%, and 4.0%.

According to statistical analysis of the organoleptic characteristics in yoghurt, there was statistical difference in taste, flavor, color, texture and overall acceptability between treated group and control group ($p<0.05$). To summarize the results of this study, the scores of taste, flavor, color, texture and overall acceptability decreased in proportion to the added amount of *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder.

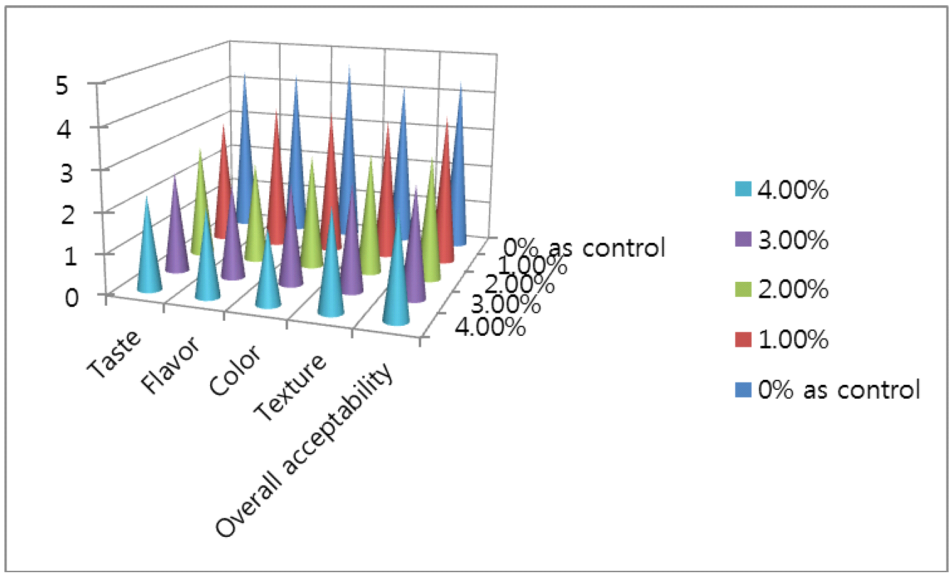

Fig. 4. Comparison of the organoleptic characteristics of yoghurt added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%).

3. Organoleptic characteristics of Kefir added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder

Kefir was prepared with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder at concentrations of 0% (as control), 1.0%, 2.0%, 3.0%, and 4.0%, respectively, and the results were summarized in Fig. 5.

The scores of taste in Kefir with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.16, 3.33, 2.5, 2.0, and 1.66, respectively. The scores of color in Kefir with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.33, 3.83, 3.33, 3.33, and 2.66, respectively. The scores of flavor in Kefir with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.0, 3.33 2.5, 2.16, and 1.66, respectively. The scores of texture in Kefir with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.5, 4.0, 3.83, 3.66, and 3.5, respectively. And the scores of overall acceptability scores in Kefir with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%) showed 4.5, 3.91, 3.66, 3.08, and 2.2, respectively.

According to statistical analysis of the organoleptic characteristics in Kefir, there was not any statistical difference in color and flavor, but in taste, texture and overall acceptability between control group and treated group (p<0.05). Subsequently, among the treated group compared with the control group (0%), the scores of taste, flavor, color texture and overall acceptability were lower in *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder-containing Kefir with 1.0%, 2.0%, 3.0%, and 4.0%.

Furthermore, Fig. 6 showed the color changes of market milk-, yoghurt-, and Kefir-

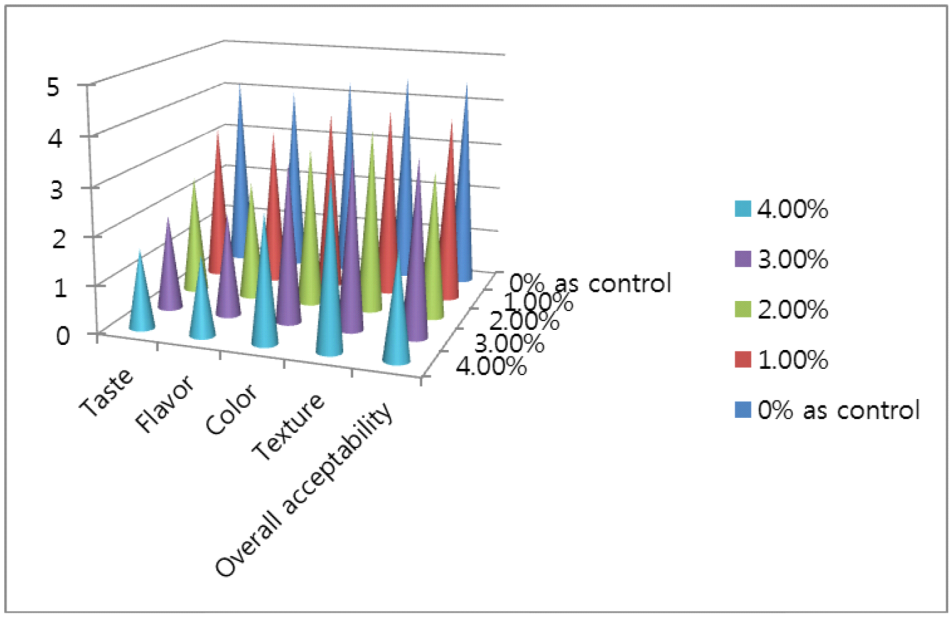

Fig. 5. Comparison of the organoleptic characteristics of Kefir added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder (control as 0%, 1.0%, 2.0%, 3.0%, and 4.0%).

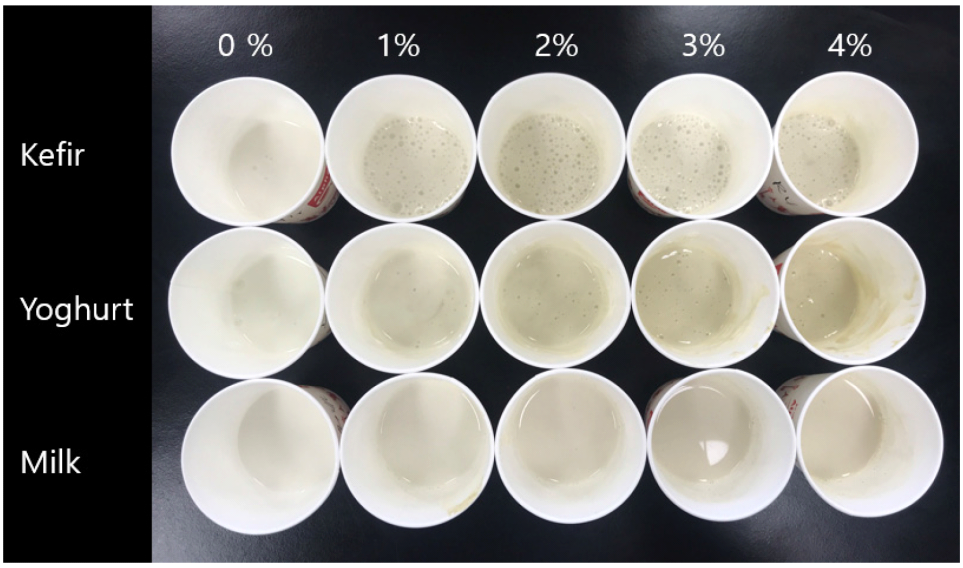

Fig. 6. The change in the color of market milk, yoghurt and Kefir by the addition of *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder as 0% (control), 1.0%, 2.0%, 3.0%, and 4.0%.

added with *Raphanus raphanistrum* subsp. *sativus*'s (radish) powder with 0% (control), 1.0%, 2.0%, 3.0%, and 4.0%. Although *Raphanus raphanistrum* subsp. *sativus* (radish) may be effective in diabetes from previous studies, many future studies will have to be conducted to improve human health and also visual improvements in dairy products when it becomes food additives.

Up to now, almost all researches published with direct links between *Raphanus raphanistrum* subsp. *sativus* (radish) and diabetes have been conducted in a nonclinical state through *in vivo* and *in vitro* [1]. According to Banihani [1], the main studies were done on *Raphanus raphanistrum* subsp. *sativus* (radish) and its extracts to have the effect on various diabetic parameters. Also all the studies were able to confirm the presence of the hypoglycemic effect of *Raphanus raphanistrum* subsp. *sativus* (radish) [1]. The water-soluble *Raphanus raphanistrum* subsp. *sativus* (radish) extract showed an advantage in the hypoglycemic response over the fat-soluble extract, but the fat-soluble extract was found to play a role in lipid metabolism [14]. It was suggested that the water-soluble extract contains insulin-like components such as polyphenolic substances or glucosidase-inhibiting components [1,14,15]. Aly et al. reported that the histo-pathological examination of the pancreas had significant changes in the streptozotocin-induced diabetic rats fed with *Raphanus raphanistrum* subsp. *sativus* (radish) of Egyptian at 10% for 6 weeks [16]. Tiwari et al. suggested that *Raphanus raphanistrum* subsp. *sativus* (radish) would have a potent antidiabetic activity, since *Raphanus raphanistrum* subsp. *sativus* (radish) could significantly reduce the starch induced-postprandial glycemic load [17]. In other words, these proofs could prove that *Raphanus raphanistrum* subsp. *sativus* (radish) and its extracts were very effective for diabetes and diabetic conditions. Also according to Baenas et al. [6], the level of blood glucose could be lower by about 33.4% after the diabetic rats fed with lyophilized *Raphanus*

raphanistrum subsp. *sativus* (radish) root-juice at 300 mg/kg of body weight and then fasted for 6 hours. Namely, the dose like this had therapeutic effect was equivalent to about 48.39 mg/kg of body weight in human [18]. Therefore, the effective therapeutic dosage was about 2903 mg of lyophilized *Raphanus raphanistrum* subsp. *sativus* (radish) root-juice in human (a man or woman) weighing 60 kg, and this amount was equal to about 0.726 kg extracted from *Raphanus raphanistrum* subsp. *sativus* (radish) [1,2].

In conclusion, *Raphanus raphanistrum* subsp. *sativus* (radish) could have the anti-diabetic activity due to various factors such as (1) the enhancement of the antioxidant defense mechanism, (2) the decrease of oxidative stress and lipid peroxidation, (3) improvement of hormonal-induced glucose hemostasis, (4) the promotion of glucose uptake and energy metabolism, (5) the reduction of glucose absorption in the intestine, and so on [1,2,6,14-16].

Therefore, future studies will need to keep the high quality of organoleptic characteristics of food including dairy products added with *Raphanus raphanistrum* subsp. *Sativus'*s (radish) powder and its extracts and to prevent diabetes.

Conflict of Interest

The authors declare no potential conflict of interest.

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