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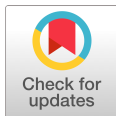
Sensory Qualities of Non-Dairy and Dairy Products Fortified with Aloe Oil: A Preliminary Study

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Abstract

Aloe vera has several beneficial health effects as it interacts with probiotics and is also a source of prebiotics, antioxidants, and other bioactive materials. Thus, there has been increasing interest in the development of beverages containing *Aloe vera*. In this investigation, sensory qualities were estimated by fortifying oil isolated from *Aloe vera* in non-dairy and dairy products at different concentrations (fortified with 1% increments from 0% to 5%). Because of the strong aroma and strong yellow color of aloe oil, the sensory quality values estimated in this study were generally low. However, the samples fortified with 1% aloe oil exhibited the best sensory quality values compared with the control. Consequently, the results of this study are valuable as preliminary findings to determine the various sensory qualities of kefir fortified with aloe oil. To improve sensory qualities in the future, it is necessary to estimate the optimal lowering of the concentration of fortified aloe oil, and assess whether aloe oil exhibits various biofunctional activities at different concentrations.

Keywords

aloe oil, sensory quality, biofunctional activity, Kefir, nondairy products

Introduction

Up to now, among the various herbs available, *A. vera* is the most popular and is receiving a lot of scientific attention [1]. In general, *Aloe* belongs to Asphodelaceae (Liliaceae) family, and is a semitropical, shrubby, or arborescent, perennial, xerophytic, succulent, pea-green color plant [2]. It is known that there are over 400 species in the genus *Aloe* [3]. However, among them, *A. vera*, *Aloe ferox*, and *Aloe arborescens* are traded worldwide [3]. *Aloe barbadensis* Miller is commonly referred to as *A. vera* [2,3]. Especially, the *Aloe* plant is very sensitive to temperature, so it is now grown on a large scale in warm tropical regions [1,3]. The main characteristic of *A. vera* plants is that the solid material is about 0.5%-1.0%, but the water content is about 99-99.5% [3].

As is known so far, it has been found that the biological benefits associated with *A. vera* are due to the polysaccharides contained in the leaf's gel [1,3,4]. Currently, gel, also called transparent pulp, is widely used in cosmetic, medical, and food fields [4,5]. Especially, since *A. vera* has various medicinal properties, many studies are being conducted centered on *A. vera* [1,3-5]. The various biological and pharmacological functions of *A. vera* gel are summarized in Fig. 1.



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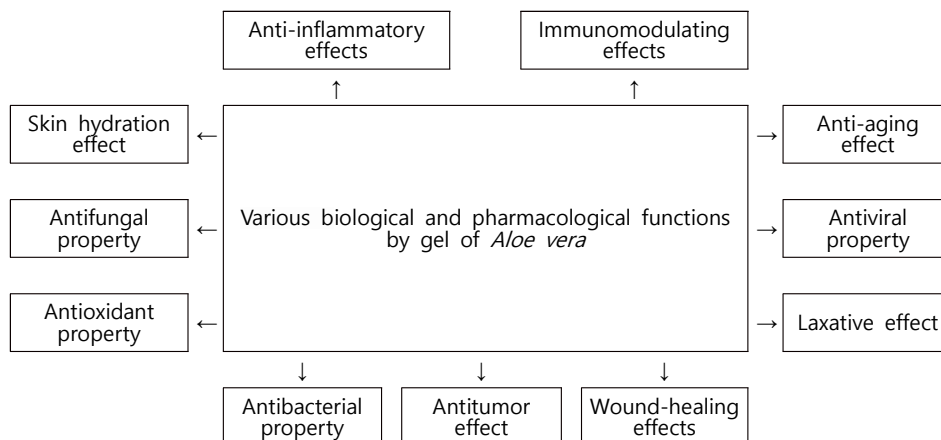


Fig. 1. Various biological and pharmacological functions by gel of *Aloe vera*.

Furthermore, it has been reported that more than 75 potentially active compounds such as enzymes, fat- and water-soluble vitamins, minerals, organic acids, simple/complex polysaccharides, phenolic compounds are contained in the solid material of *A. vera* [3,6]. But, during processing and storage, the physical stability mechanisms and rheological behavior of suspensions are greatly affected. This phenomenon occurs because both aloe gel and pulp contained large amounts of insoluble polymer particles. [7]. Therefore, continuous research is needed to solve these problems mentioned above. Then it can be used more actively in the food industry.

Next, *A. vera* is also known as a useful secondary metabolite [8,9]. The main secondary metabolites are anthraquinones and tricyclic aromatic quinines, which are abundantly present [3]. *Aloe* emodin and chrysophanol are the main components of natural anthraquinone derivatives [10]. It is known that the tricyclic aromatic quinine of *Aloe* is synthesized through the type III polyketide biosynthetic pathway [3]. In other words, aloesin, aloin and aloe-emodin (oxidation products of aloin) are the most important secondary metabolites found in gel of *A. vera* [3]. In addition, it is reported that the physiological activity of many secondary metabolites of plants has strong anti-inflammatory, antioxidant activity, lipid-lowering, and so on [11-13]. It has even been approved by the US Food and Drug Administration (FDA) for development research in the treatment of cancer and AIDS using *A. vera* [3].

Therefore, the method of fortifying aloe oil containing various functional substances directly to nondairy or dairy products is recommended. In this way, the functional substances of aloe oil in food can be further activated, which can enhance human health benefits and upgrade the sensory quality. However, studies on the estimation of sensory quality after direct application of aloe oil to various nondairy or dairy products are lacking.

Subsequently, the purpose of this study is to estimate the sensory quality by fortifying aloe oil of diverse concentrations to soy milk, cow milk, yoghurt, and Kefir, respectively.

Materials and Methods

1. Aloe oil

The aloe oil used in this study was purchased from 100% Live Natural Aloe Oil (30 mL) manufactured by Hermani General Trading LLC (UAE), and also was approved as a food additive.

2. Sample preparation of nondairy and dairy products fortified with aloe oil

Aloe oil was fortified to nondairy product (soy milk) and dairy products (cow milk, yogurt, Kefir) at diverse concentrations (fortified by adding 1% increments from 0% up to 5%). Then, samples of soy milk, cow milk, yogurt, and Kefir fortified with aloe oil were kept at $7\pm 2^{\circ}\text{C}$ until estimation. All samples were purchased from a supermarket located east of Seoul, and a description of the samples used in this study was as follows. Null-Additive Soybean Milk produced by Hanmi Healthcare (Korea) was used as a sample of soy milk, Konkuk Milk produced by Konkuk Dairy & Ham was used as a sample of cow milk, Yoplait Only 2 Plain produced by Binggrae (Korea) was used as a sample of yoghurt, and Kefir 12 Plain produced by Maeil Dairies (Korea) was used as a sample of Kefir.

3. The pH score of nondairy and dairy products fortified with aloe oil

The score of pH of nondairy product (soy milk) and dairy products (cow milk, yogurt, Kefir) fortified with aloe oil at diverse concentrations were estimated by the Thermo Scientific™ Orion™ Star A211 pH Benchtop Meter (Thermo Fisher Scientific, USA).

4. The sensory quality of nondairy and dairy products fortified with aloe oil

Nondairy product (soy milk) and dairy products (milk, yogurt, Kefir) with diverse concentrations of aloe oil fortified were prepared and kept at $7\pm 2^{\circ}\text{C}$ until estimation. The panel of seven well-trained researchers estimated the sensory quality of soy milk, cow milk, yogurt, and Kefir fortified with diverse concentrations of aloe oil. All samples in this study were randomly estimated in single-use plastic cups (30 mL) at 10°C . The category of sensory quality of all samples estimated in this study included texture, color, taste, and overall acceptability, and were estimated on a scale of 1 (very bad) to 5 (excellent) based on the 5-point hedonistic score. And 2, 3, and 4 mean bad, average, and good, respectively.

5. Statistical data analysis

All results obtained three times in two separate experiments were statistically estimated with GraphPad Prism 5 (GraphPad Software, USA), and were presented as mean \pm SD. Also “ $p<0.05$ ” was indicated if there was a statistically significant difference.

Results and Discussion

1. The pH score of dairy and nondairy products fortified with aloe oil

The score of pH of aloe oil was approximately 1.7 (data not shown), and then the score of pH of soy milk, cow milk, yoghurt, and Kefir without fortified with aloe oil was 6.69, 4.17, 4.15, and 6.73, respectively (Fig. 2). The score of pH of soy milk, cow milk, yoghurt, and Kefir fortified with diverse concentrations (fortified by adding 1% increments from 0% up to 5%) of aloe oil exhibited similar to that of soy milk cow milk, yoghurt, and Kefir with no addition of aloe oil in this study (Fig. 2). Hence, no statistically significant difference was observed between the treated group and the control group in the score of pH.

There was no statistically significant difference in the results of previous researches that studied the outline in pH score when vegetable oil was fortified to dairy or food products [14,15]. Also, the results of the outline in pH score in this study also showed a similar trend.

2. The sensory quality of soy milk fortified with aloe oil

Fig. 3 exhibited the outline of sensory quality of soy milk estimated by seven panels. Soy milk was fortified with diverse concentrations (fortified by adding 1% increments from 0% up to 5%) of aloe oil. When aloe oil was fortified to soy milk from 1% to 5%, the score of texture varied from 4.8 to 4.5, the score of color varied from 3.7 to 1.3, the score of flavor varied from 3.3 to 1.2, and the score of overall acceptability varied from 2.8 to 1.2, which was lower than 5 of the control group (Fig. 3).

Based on the statistical estimation of the sensory quality of soy milk obtained in this study, the statistically significant difference was observed between the treated group and the control group in texture, color, flavor, and overall acceptability ($p < 0.05$). When the addition amount of aloe oil was increased, the score of sensory quality of texture, color, flavor, and overall acceptability tended to decrease (Fig. 3). In this study, the soy milk

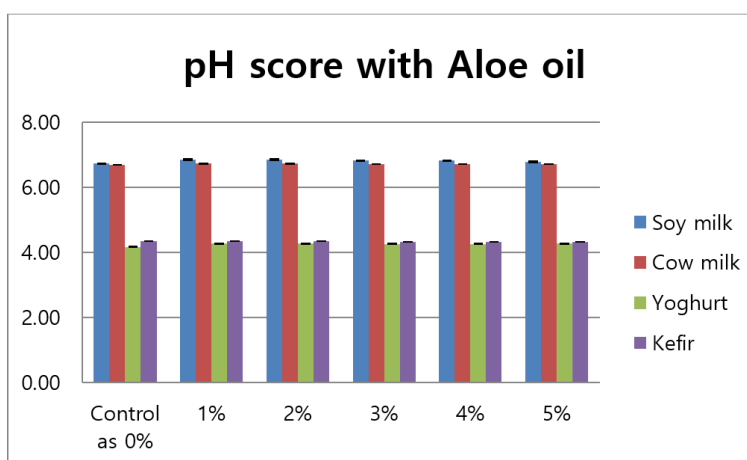


Fig. 2. The score of pH of soy milk, cow milk, yoghurt, and kefir fortified with aloe oil.

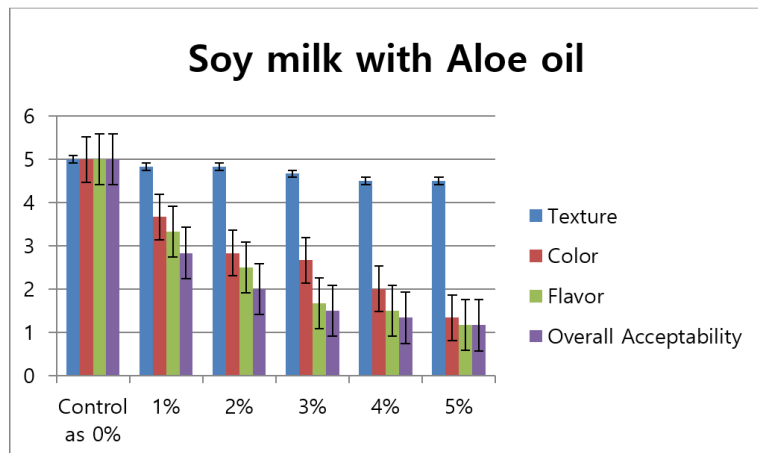


Fig. 3. The sensory quality of soy milk fortified with diverse concentrations of aloe oil.

fortified with 1% of aloe oil exhibited the best results compared with control group.

3. The sensory quality of cow milk fortified with aloe oil

Fig. 4 exhibited the outline of sensory quality of cow milk estimated by seven panels. Cow milk was fortified with diverse concentrations (fortified by adding 1% increments from 0% up to 5%) of aloe oil. When aloe oil was added to cow milk from 1% to 5%, the score of texture varied from 4.8 to 4.0, the score of color varied from 2.8 to 1.05, the score of flavor varied from 2.2 to 1.0, and the score of overall acceptability varied from 1.8 to 1.0, which was generally lower than 5.0 of the control group (Fig. 4).

Based on the statistical estimation of the sensory quality of cow milk obtained in this study, the statistically significant difference was observed between the treated group and the control group in texture, color, flavor, and overall acceptability ($p < 0.05$). When the addition amount of aloe oil was increased, the score of sensory quality of texture, color, flavor, and overall acceptability tended to decrease (Fig. 4). In this study, the cow milk

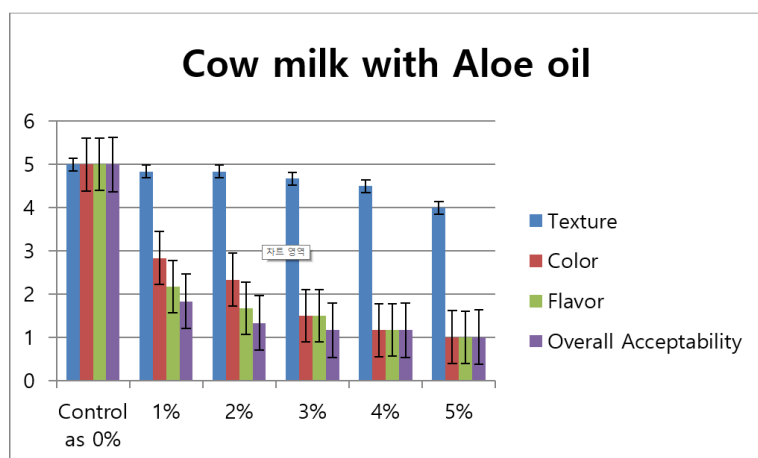


Fig. 4. The sensory quality of cow milk fortified with diverse concentrations of aloe oil.

fortified with 1% of aloe oil exhibited the best results compared with control group.

4. The sensory quality of yoghurt fortified with aloe oil

Fig. 5 exhibited the outline of sensory quality of yoghurt estimated by seven panels. Yoghurt was fortified with diverse concentrations (fortified by adding 1% increments from 0% up to 5%) of aloe oil. When aloe oil was fortified to yoghurt from 1% to 5%, the score of texture varied from 5.0 to 4.7, the score of color varied from 4.2 to 3.2, the score of flavor varied from 2.8 to 1.2, and the score of overall acceptability varied from 2.8 to 1.0, which was generally lower than 5.0 of the control group (Fig. 5). But, the score of texture was very similar to that of the control group, and there was no statistically significant difference.

Based on the statistical estimation of the sensory quality of yoghurt obtained in this study, the statistically significant difference was observed between the treated group and the control group in color, flavor, and overall acceptability except texture ($p < 0.05$). When the addition amount of aloe oil was increased, the score of sensory quality of color, flavor, and overall acceptability tended to decrease except texture (Fig. 5). In this study, the yoghurt fortified with 1% of broccoli oil exhibited the best results compared with control group.

5. The sensory quality of Kefir fortified with aloe oil

Fig. 6 exhibited the outline of sensory quality of Kefir estimated by seven panels. Kefir was fortified with diverse concentrations (fortified by adding 1% increments from 0% up to 5%) of aloe oil. When aloe oil was fortified to kefir from 1% to 5%, the score of texture varied from 5.0 to 4.7, the score of color varied from 4.7 to 2.7, the score of flavor varied from 3.5 to 1.2, and the score of overall acceptability varied from 3.3 to 1.2, which was lower than 5 of the control group (Fig. 6). But, the score of texture was very similar to that of the control group, and there was no statistically significant difference.

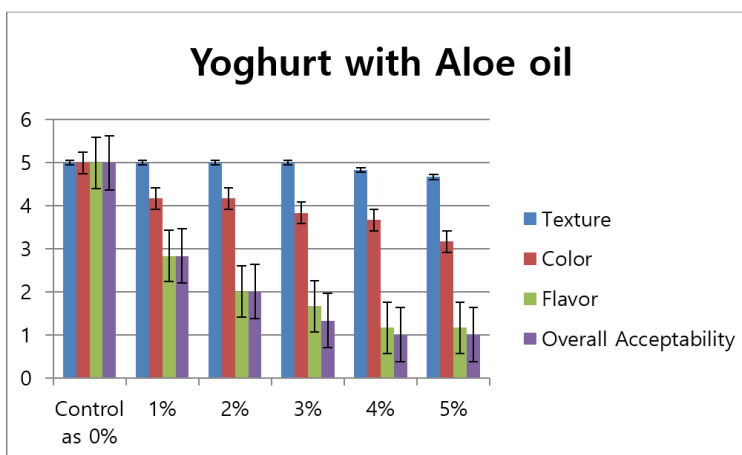


Fig. 5. The sensory quality of yoghurt fortified with diverse concentrations of aloe oil.

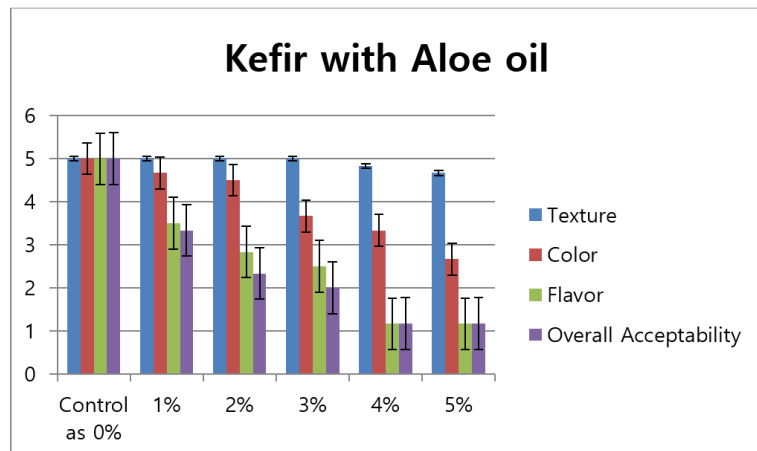


Fig. 6. The sensory quality of Kefir fortified with diverse concentrations of aloe oil.

Based on the statistical estimation of the sensory quality of Kefir obtained in this study, the statistically significant difference was observed between the treated group and the control group in color, flavor, and overall acceptability except texture ($p < 0.05$). When the addition amount of aloe oil was increased, the score of sensory quality of color, flavor, and overall acceptability tended to decrease except texture (Fig. 6). In this study, the Kefir added with 1% of aloe oil exhibited the best results compared with control group.

Also, Fig. 7 exhibited the process of color change in soy milk, cow milk, yoghurt, and Kefir fortified with diverse concentrations of aloe oil. In this study, soy milk, cow milk, yoghurt, and Kefir fortified with diverse concentrations (fortified by adding 1% increments from 0% up to 5%) of aloe oil were observed to change to a very strong yellow color (Fig. 7). Hence, in the sensory quality of soy milk, cow milk, yoghurt, and Kefir to which aloe oil was fortified, the score of color exhibited a tendency to decrease a lot (Fig. 3-6).

The contents of comparative review of the results of other previous studies similar to this study were summarized in detail below. After preparing fermented milk by adding *A. vera* gel powder, various effects during storage were investigated by Basannavar et al. [16]. The ACE inhibitory effect was significantly increased in fermented milk with *A. vera* gel powder (1% w/v) [16]. Since *A. vera* showed various functionalities that helped health, it was evaluated that it could be used as a food additive. And, Ikram et al. [17] investigated the characteristics of yogurt prepared by adding *A. vera* gel instead of milk fat. Yogurt with *A. vera* gel had a better texture and also showed high preference in consumer's evaluations [17]. Especially, yogurt prepared by adding 3% *A. vera* gel to buffalo milk with 1% milk fat showed the best physicochemical and sensory quality [17]. This trend was similar to the sensory quality of yogurt and kefir, which belong to the fermented milk evaluated in this study. Next, 2 types of *A. vera* juice were prepared by fermentation of newly isolated *Enterococcus faecium* and commercially available *Lactococcus lactis* [18]. Most of the lactic acid was produced by using the

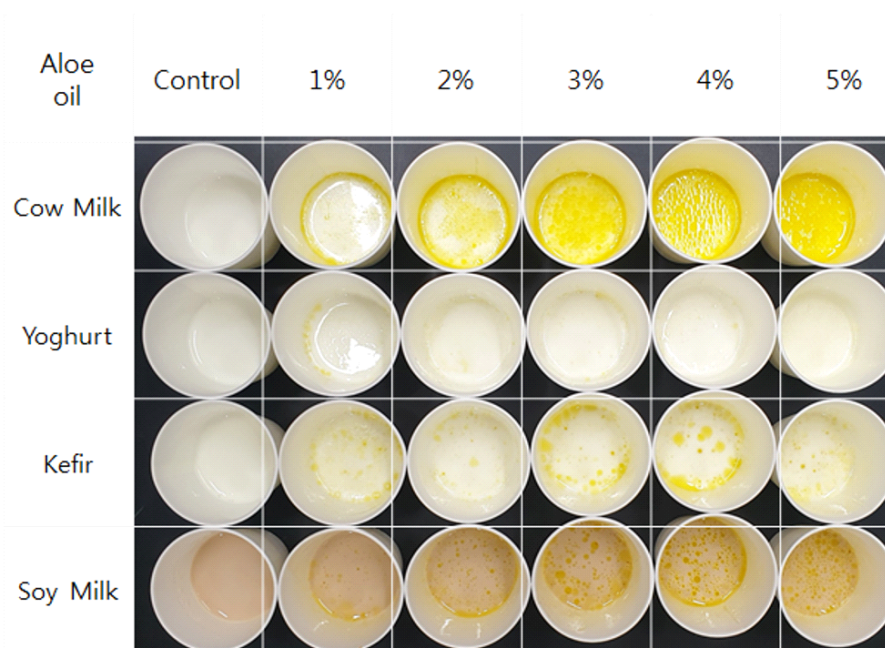


Fig. 7. The color change of soy milk, cow milk, yoghurt, and Kefir fortified with diverse concentrations of aloe oil.

added *A. vera* sugar as a carbon source for both lactic acid bacteria. Also, although antioxidant activity in *A. vera* juice showed a tendency to increase, the amounts of SCFA and total phenol was not affected during fermentation [18]. Therefore, *A. vera* not only had a variety of synergistic effects with probiotic lactic acid bacteria, but could also be a source of prebiotics, antioxidants and other bioactive materials [18]. For this reason, it could be evaluated that *A. vera* is suitable for the development of an *A. vera* drink with functionality because it provides many benefits to human health.

In conclusion, the sensory qualities obtained in this study are summarized as follows. Due to the strong aroma and strong yellow-color of aloe oil, when diverse concentrations were fortified to cow milk, yoghurt, and soymilk, the overall balance showed a tendency to be very poor. However, in the case of kefir, the characteristic flavor tends to be improved when the concentration of aloe oil fortified was low, but as the concentration of aloe oil fortified increased, the palatability tended to decrease due to the strong flavor of aloe oil. In other words, the characteristic grass (or herb) flavor and yellow strength of aloe oil were strong, so the scores of color and flavor were very low in the sensory quality. And above all, it is considered to be very valuable as the first study to estimate various sensory qualities by fortifying aloe oil to kefir.

In the future, when the added concentration of aloe oil is subdivided to less than 1%, first check the concentration with little difference in score from the control group in the sensory quality. Then, it is necessary to estimate the various biofunctional activities that aloe oil could exhibit at that concentration.

Conflict of Interest

The authors declare no potential conflict of interest.

Acknowledgements

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