pISSN 2733-4554
eISSN 2733-4562

J. Dairy Sci. Biotechnol. 2023;41(1):26-33
https://doi.org/10.22424/jdsb.2023.41.1.26

ARTICLE

Evaluation of Sensory Profile of Milk Analogs Containing Clove Oil: A Preliminary Study

Tae-Jin Kim[1†], Kun-Ho Seo[1†], Jung-Whan Chon[2], Hye-Young Youn[1], Hyeon-Jin Kim[1], Hajeong Jeong[3], Seok-Hyeong Kang[3,4], Won-Uk Hwang[3], Dongkwan Jeong[5], and Kwang-Young Song[1,3*]

[1]Center for One Health and Department of Public Health, College of Veterinary Medicine, Konkuk University, Seoul, Korea
[2]Department of Companion Animal Health Care, Kyung-in Women's University, Inchon, Korea
[3]Department of Companion Animal and Department of Animal Health, Seojeong University, Yangju, Korea
[4]Department of Animal Science and Technology, Konkuk University, Seoul, Korea
[5]Department of Food and Nutrition, Kosin University, Busan, Korea

Received: March 13, 2023
Revised: March 23, 2023
Accepted: March 23, 2023

†These authors contributed equally to this study.

*Corresponding author :
Kwang-Young Song
Department of Companion Animal and Department of Animal Health, Seojeong University, Yangju, Korea
Tel : +82-31-860-5075
Fax : +82-31-859-6064
E-mail : drkysong@gmail.com

ORCID
Tae-Jin Kim
https://orcid.org/0000-0003-2776-7319
Kun-Ho Seo
https://orcid.org/0000-0001-5720-0538
Jung-Whan Chon
https://orcid.org/0000-0003-0758-6115
Hye-Young Youn
https://orcid.org/0000-0003-4626-5859
Hyeon-Jin Kim
https://orcid.org/0000-0002-7914-7771
Hajeong Jeong
https://orcid.org/0000-0001-6346-5081
Seok-Hyeong Kang
https://orcid.org/0000-0001-6210-5092
Won-Uk Hwang
https://orcid.org/0000-0002-7793-1650

Abstract

Eugenol, which can be extracted from clove oil, is a phenolic aromatic compound and has been found to have antibacterial, antiviral, antifungal, anticancer, anti-inflammatory, and antioxidant functions. Consequently, clove oil has long been used in several fields (food, medicine, skincare). Hence, in this study, the sensory profile of clove oil contained in milk analogs (almond, oat, and soy milks) was evaluated at different amounts (added at 0.25%-0.5% increments from 0% to 1.5%). Because of the strong scent of clove oil, the value of the evaluation for sensory profile determined in this study tended to be low. However, compared with the control group, good values in the evaluation for the sensory profile were found in all samples containing 0.25% of clove oil. We evaluated clove oil contained in milk analogs to help increase their sales through products with improved functionality.

Keywords

clove oil, sensory profile, milk analogs, bioactive properties

Introduction

In general, oil plays an important vital role in human nutrition, various bioactive materials, essential fatty acids, flavor materials, and so on [1,2]. Among a variety of oil, clove oil was a plentiful resource of omega-3 polyunsaturated fatty acids, and also could be easily extracted using traditional method [1]. As already known, clove belonged to the family of *Myrtaceae* and was commonly called *Eugenia caryophyllata* herb [2,3]. In clove oil, phenylpropanoid (eugenol) and its derivatives accounted for most, but humulene and caryophyllene were found to be small [4]. In particular, it has been reported that clove oil has various bioactive compounds that exhibit antimicrobial activity as well as strong antioxidant activity [5]. Various bioactive functions of clove oil according to various research results so far are summarized in detail in Fig. 1 [1-7].

In other words, various biochemical properties of clove oil have the function of analgesic, antibacterial, anticancer, antioxidant, insecticide, preservative, and so on [1-7]. For these reasons, clove oil will be widely applied to various industries (biomedicine, cosmetics, food, hygiene, packaging, pharmaceuticals) in the future. For example, recently, clove oil, which was a natural colorant, flavoring, and preservative, has been used in food [8,9].

Dongkwan Jeong
https://orcid.org/0000-0002-6305-794X
Kwang-Young Song
https://orcid.org/0000-0002-5619-8381

Because clove oil had the biochemical properties which had the antibacterial, antifungal, antioxidant and insecticidal characteristics, it has been widely used in cooking as a flavoring component and antibacterial substance for many centuries [9,10]. Also clove oil as antiseptic was often used for the treatment of oral infections [11,12]. Furthermore, many studies have reported that the growth of mold, yeast and bacteria is inhibited by clove oil [9–12]. For example, when contained to clove oil in cheese, it was found to inhibit *Listeria monocytogenes* and *Salmonella* Enteritidis effectively [2,7–10]. The main reason for this mechanism is that clove oil contains a large amount of eugenol [2,5,12].

Since clove oil generally has phenol components as well as eugenol, these components could denature proteins as well as interact with phospholipids in cell membranes [2,10,12]. Therefore, it was found to have a direct effect on the growth-inhibition of a variety of gram negative & gram positive bacteria and yeast [2,10,12]. However, these effects are directly affected by environmental variables such as the type and amounts of biocide, the type of microorganism, pH value, temperature, the presence of organic materials, and so on [2,12].

Therefore, because of the excellent advantages of clove oil, there is an increasing demand for obtaining effects such as various additional bioactive functions by directly adding clove oil to food [8–10]. But, researches on the evaluation for sensory profile after direct (or indirect) addition of clove oil to several milk analogs are still insufficient.

Thus, the target of this study was to determine the evaluation for the sensory profile contained with clove oil of different amounts to various milk analogs (almond milk, oat milk, and soy milk).

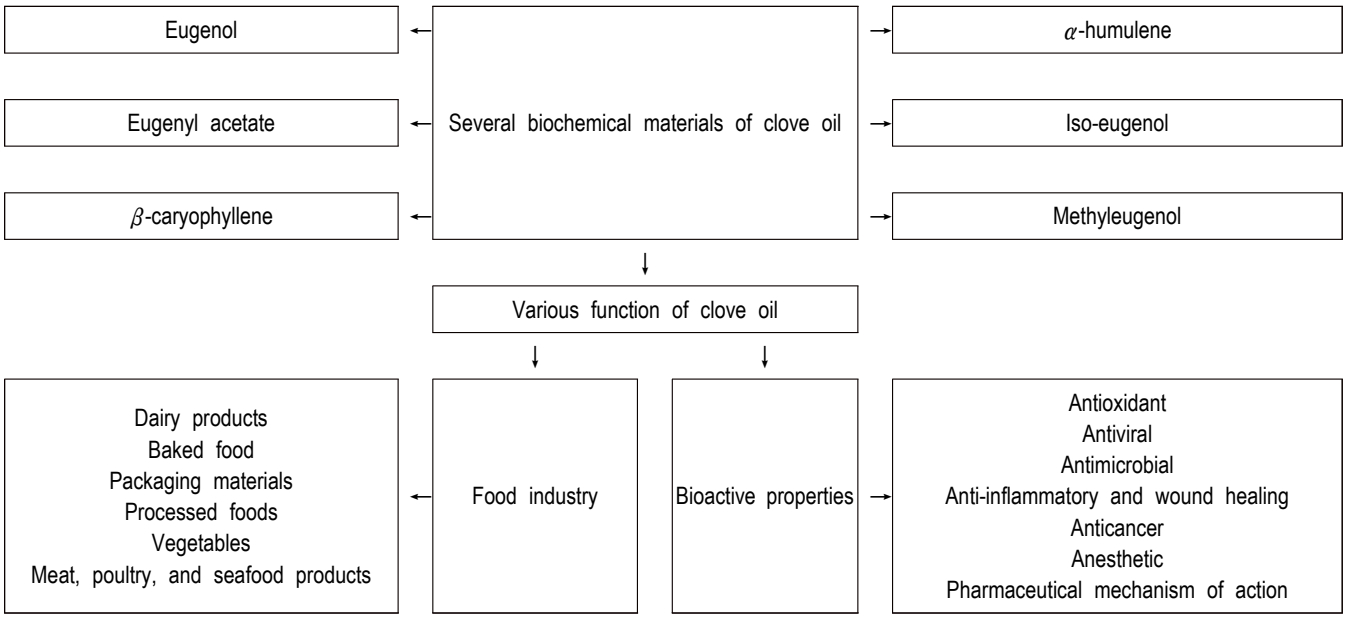

Fig. 1. Several biochemical materials and various function of clove oil.

Materials and Methods

1. The type of clove oil

In this study, the clove oil was purchased and used as Herbal Oil 100 mL – Clove, which was produced by Hemani Herbal LLC (USA) and was also a product recognized as safe even when contained to food.

2. Preparation of various milk analogs contained with clove oil

Clove oil was directly contained with various milk analogs at different amounts (add clove oil at a rate of 0.25% from 0% to 0.5%, and at a rate of 0.5% from 0.5% to 1.5%). All samples of various milk analogs contained with clove oil were storage at 10℃ until analysis. The description of the samples, which were obtained at the large-scale supermarket in Seoul, used in this study is detailed in Table 1.

3. The value of pH of various milk analogs contained with clove oil

The value of pH of various nondairy products contained with different amounts of clove oil were evaluated using by pH meter (Orion Star A211 Benchtop pH Meter, Thermo Fisher Scientific, USA).

4. Evaluation for sensory profile of various milk analogs contained with clove oil

Various milk analogs with different amounts of clove oil contained were made and then storage at 10℃ until analysis. The appraiser's panel consisted of five researchers reviewed the evaluation for sensory profile of various milk analogs contained with different amounts of clove oil.

All samples were arbitrarily determined in single-use holder (50 mL) kept at 10℃. In this study, the evaluation for sensory profile of all samples tested was made up 4 different category (texture, color, taste, and overall acceptability) and were determined by the five-point hedonistic grade.

5. Statistical evaluation

All data taken in this study was evaluated using the statistical evaluation program

Table 1. The general composition of various milk analogs tested in this study

Type		Name of product	Name of manufac-turer	General composition								
				Sodium (mg/100 mL)	Carbohy-drate (g/100 mL)	Sugar (g/100 mL)	Fat (g/100 mL)	Trans fat (g/100 mL)	Saturated fat (g/100 mL)	Cholesterol (mg/100 mL)	Protein (g/100 mL)	Calcium (mg/100 mL)
Milk ana-logs	Almond milk	Almond Breeze	Maeil Dairies	75	1.5	0.1	1.4	0	0.1	0	0.6	115
	Oat milk	Amazing Oat Unsweeten-ed	Maeil Dairies	49	2.1	0.4	0.8	0	0.1	0	0.8	116
	Soy milk	Null-Additive Soybean Milk	Hanmi Healthcare	34	2.6	0.5	1.9	0	0.3	0	3.7	-

(GraphPad Prism 5, GraphPad Softward, USA).

Results and Discussion

1. The value of pH of various milk analogs contained with clove oil

The value of pH of various milk analogs (almond milk, oat milk, and soy milk) without contained with clove oil was 6.75, 7.30, and 8.49 (Fig. 2), respectively. The value of pH of clove oil was about 3.42 (data not shown). And, in this study, the value of pH of various milk analogs contained with different amounts (add clove oil at a rate of 0.25% from 0% to 0.5%, and at a rate of 0.5% from 0.5% to 1.5%) exhibited similar to that of various milk analogs with no addition of clove oil (Fig. 2). This result demonstrated a similar tendency to various previous studies [10].

2. Evaluation for sensory profile of various milk analogs contained with clove oil

Figs. 3-5 demonstrated the value of the evaluation for sensory profile of almond, oat milk, and soy milk investigated by the appraiser's panel, respectively. And various milk analogs were contained with different amounts (add clove oil at a rate of 0.25% from 0% to 0.5%, and at a rate of 0.5% from 0.5% to 1.5%), respectively.

According to the statistical analysis of the evaluation for sensory profile of almond milk, oat milk, and soy milk, the significant differences were statistically observed between the treated and control groups in categories of color, flavor, and overall acceptability except for texture ($p<0.05$). In other words, as the contained amounts of clove oil increased, the value of the evaluation for sensory profile which were color, flavor, and overall acceptability tended to decrease, except for texture (Figs. 3-5). Hence, in this study, all milk analogs with 0.25% clove oil demonstrated the best results.

Then, Fig. 6 demonstrated the trendency of color alteration in various milk analogs contained with different amounts of clove oil. Various milk analogs contained with

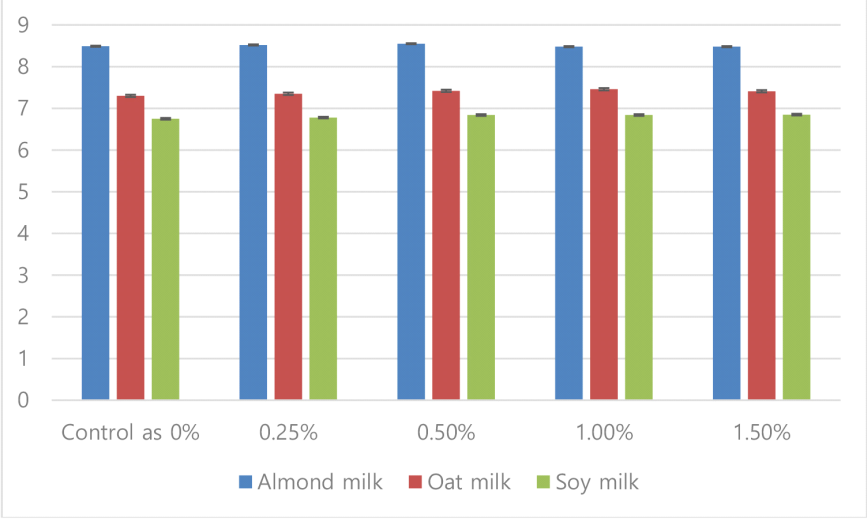

Fig. 2. The value of pH of various milk analogs contained with clove oil.

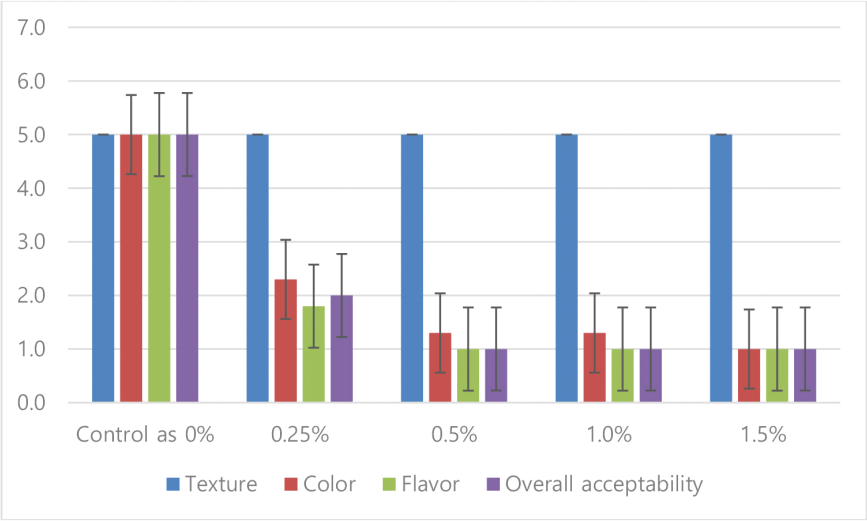

Fig. 3. Evaluation for sensory profile of almond milk contained with different amounts of clove oil.

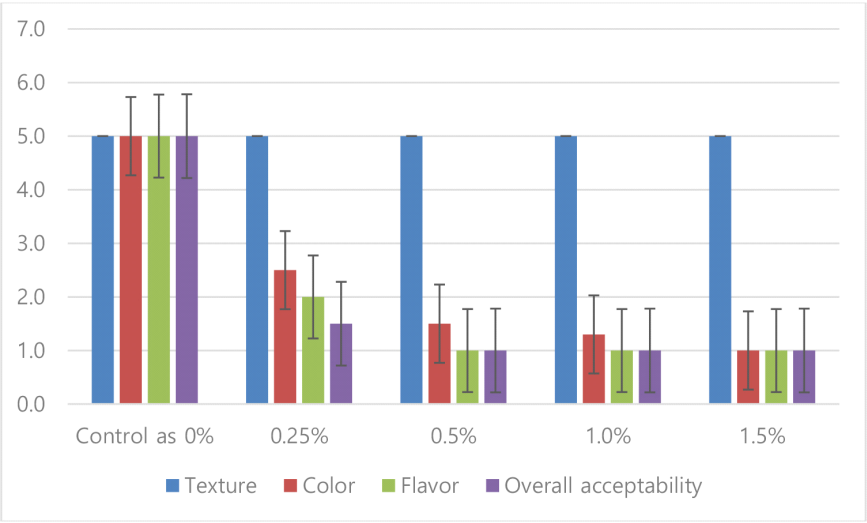

Fig. 4. Evaluation for sensory profile of oat milk contained with different amounts of clove oil.

different amounts (add clove oil at a rate of 0.25% from 0% to 0.5%, and at a rate of 0.5% from 0.5% to 1.5%) were observed that it turned to the weak yellow (Figs. 3-6).

Above all, in this study, a method of directly adding clove oil to milk analogs at different amounts was used. As shown in Fig. 6, it was confirmed that the appearance was not good because the clove oil was not mixed evenly with the milk analogs due to the phenomenon that the oil layer floated to the surface. Therefore, in order to solve these appearance phenomena, an appropriate emulsifier must first be selected so that clove oil can be well mixed with milk analogs. Then, additional processes such as homogenization must be performed. It is believed that these processes mentioned above can be applied to actual product production. Hence, in order to improve these problems in the future, research should be conducted in various aspects.

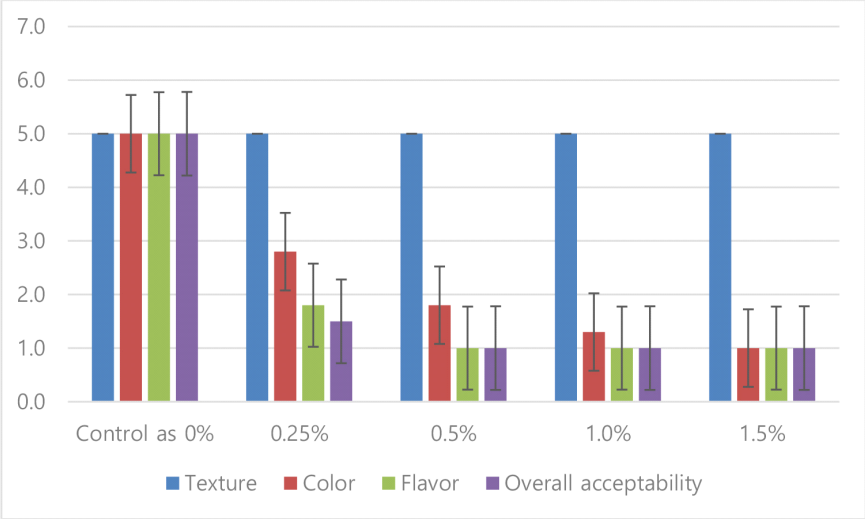

Fig. 5. Evaluation for sensory profile of soy milk contained with different amounts of clove oil.

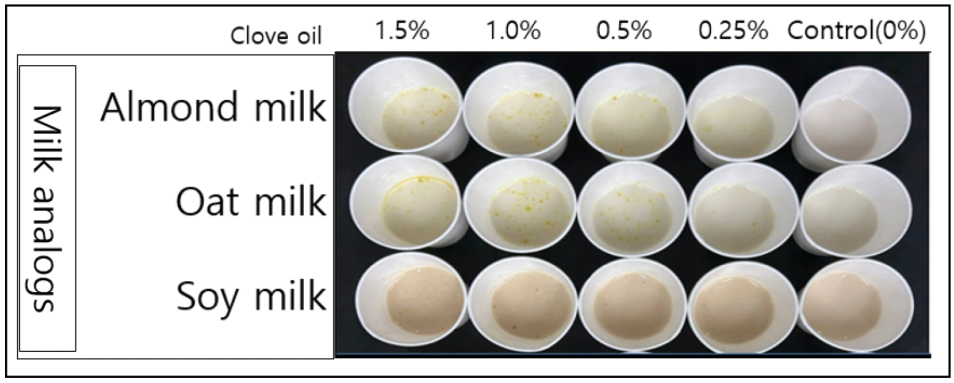

Fig. 6. Trend of color alteration in milk analogs contained with different amounts of clove oil.

Next, the additional evaluation comments of the appraisers who participated in this study were summarized as follows. First, clove oil did not match well with various milk analogs. Second, the distinctive smell of clove oil was strong enough to arouse a sense of rejection. Third, when adding yellow clove oil to various milk analogs, it was not visually good because it did not mix well. Therefore, it was evaluated that solutions to the above-mentioned parts should be preceded. Nevertheless, it is very worthwhile as the first research to estimate the evaluation for sensory profile by directly supplementing clove oil to various milk analogs such as almond milk, oat milk, soy milk.

Consequently, several processes are involved in producing edible clove oil [1,13]. First, it is purified, followed by bleaching and deodorization to eliminate coloring substances, odorous materials, total impurities, and so on [1]. Recently, it has been possible to manufacture substances that not only improve functionality but also provide health benefits from clove oil by using various methods [1,13]. As far as is known, clove oil could be utilized to put various foods (bread, cakes, cheddar cheese, drinking yogurt,

fermented milk, flavored yogurt, mozzarella cheese, processed cheese, salad dressing, and so on) [1-12,14,15]. Also, clove oil can be used in medicine, food fortification, and animal feed [1,2,9,10,15]. Then, additional research concentrating on the production of various milk analogs with several functionalities using clove oil must be conducted.

Conflict of Interest

The authors declare no potential conflict of interest.

Acknowledgements

This work was supported by the Konkuk University Researcher Fund, 2022.

References

1. Nadeem M, Imran M, Din A, Khan A. Clove oil. In: Nayik GA, Ansari MJ, editors. Essential oils: extraction, characterization and applications. 1st ed. New York, NY: Academic Press; 2023, p. 325-344.
2. Kumar Pandey V, Shams R, Singh R, Dar AH, Pandiselvam R, Rusu AV, et al. A comprehensive review on clove (Caryophyllus aromaticus L.) essential oil and its significance in the formulation of edible coatings for potential food applications. Front Nutr. 2022;9:987674.
3. Hadidi M, Pouramin S, Adinepour F, Haghani S, Jafari SM. Chitosan nanoparticles loaded with clove essential oil: characterization, antioxidant and antibacterial activities. Carbohydr Polym. 2020;236:116075.
4. El Asbahani A, Miladi K, Badri W, Sala M, Aït Addi EH, Casabianca H, et al. Essential oils: from extraction to encapsulation. Int J Pharm. 2015;483:220-243.
5. Chen X, Ren L, Li M, Qian J, Fan J, Du B. Effects of clove essential oil and eugenol on quality and browning control of fresh-cut lettuce. Food Chem. 2017;214:432-439.
6. Aguilar-González AE, Palou E, López-Malo A. Antifungal activity of essential oils of clove (Syzygium aromaticum) and/or mustard (Brassica nigra) in vapor phase against gray mold (Botrytis cinerea) in strawberries. Innov Food Sci Emerg Technol. 2015; 32:181-185.
7. Donsì F, Annunziata M, Sessa M, Ferrari G. Nanoencapsulation of essential oils to enhance their antimicrobial activity in foods. LWT-Food Sci Technol. 2011;44:1908-1914.
8. Sebaaly C, Jraij A, Fessi H, Charcosset C, Greige-Gerges H. Preparation and characterization of clove essential oil-loaded liposomes. Food Chem. 2015;178:52-62.
9. Hassanin AM, Soliman SA, Abdella SAS, A Shaaban H. Antifungal activity of some essential oils emulsions against fungi contaminating Ras cheese. Pak J Biol Sci.

2021;24:1350-1358.
10. Chon JW, Seo KH, Bae D, Kim B, Jeong D, Song KY. Antibacterial activity of clove oil against foodborne pathogenic bacteria and sensory attributes in clove oil-enriched dairy products: a preliminary study. J Dairy Sci Biotechnol. 2020;38:197-206.
11. Cortés-Rojas DF, de Souza CRF, Oliveira WP. Clove (Syzygium aromaticum): a precious spice. Asian Pac J Trop Biomed. 2014;4:90-96.
12. Nuñez L, Aquino MD. Microbicide activity of clove essential oil (Eugenia caryophyllata). Braz J Microbiol. 2012;43:1255-1260.
13. Cadirci BH, Citak S. A comparison of two methods used for measuring antagonistic activity of lactic acid bacteria. Pak J Nutr. 2005;4:237-241.
14. Zahid MA, Choi JY, Seo JK, Parvin R, Ko J, Yang HS. Effects of clove extract on oxidative stability and sensory attributes in cooked beef patties at refrigerated storage. Meat Sci. 2020;161:107972.
15. Hu Q, Zhou M, Wei S. Progress on the antimicrobial activity research of clove oil and eugenol in the food antisepsis field. J Food Sci. 2018;83:1476-1483.
16. Han X, Parker TL. Anti-inflammatory activity of clove (Eugenia caryophyllata) essential oil in human dermal fibroblasts. Pharm Biol. 2017;55:1619-1622.