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ARTICLE

Physiochemical Analysis, Antioxidant Effects, and Sensory Characteristics of Quark Cheese Supplemented with Ginseng Extract

Kee-Tae Kim[1], Ji Eun Hwang[2], Su Jin Eum[3], and Hyun-Dong Paik[2,*]

[1]Research Laboratory, WithBio Inc., Seoul 05029, Korea
[2]Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 05029, Korea
[3]Division of Strategic Food Research, Korea Food Research Institute, Wanju 55365, Korea

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***Corresponding author** : Hyun-Dong Paik
Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 05029, Korea
Tel: +82-2-2049-6011
Fax: +82-2-455-8082
E-mail: hdpaik@konkuk.ac.kr

***ORCID**
Kee-Tae Kim
https://orcid.org/0000-0003-2412-7092
Ji Eun Hwang
https://orcid.org/0000-0003-1581-0404
Su Jin Eum
https://orcid.org/0000-0003-2113-3024
Hyun-Dong Paik
https://orcid.org/0000-0001-9891-7703

Abstract The objective of this study was to evaluate physicochemical and sensory properties, the texture profile, and antioxidant activity of ginseng extract-supplemented quark cheese as a new cheese product intended to improve public health. After addition of less than 1.0% ginseng extract, the moisture content of quark significantly decreased, while fat and protein levels increased, although microbial counts and lactose and ash contents were not affected significantly ($p<0.05$). In terms of color, L* values decreased significantly with increasing concentration of ginseng extract, while a* values increased significantly ($p<0.05$). The results of texture profiling showed that cohesiveness and springiness were unaffected, whereas hardness, gumminess, and chewiness increased significantly. The 2,2′-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS) radical-scavenging activities of the cheese fortified with 0%, 0.5%, or 1.0% of the ginseng extract were 4.22%±0.12%, 20.14%±1.34%, and 56.32%±1.54%, respectively. The results of sensory analysis indicated that bitterness, ginseng odor, and aftertaste significantly improved with increasing concentration of ginseng extract ($p<0.05$). However, there was no significant difference in the overall quality attributes of quark cheese between the no-supplement control and samples with less than 0.5% of the ginseng extract ($p>0.05$), suggesting that these products could help to promote public health as functional foods.

Keywords quark cheese, ginseng extract, antioxidant effect, texture analysis, sensory evaluation

Introduction

Recently, the development and production of high-value dairy products has increased to meet the demand for biofunctional food products, driven by the increasing interest of consumers in their health and well-being (Swensson et al., 2017). Many biotech companies have developed new dairy products as functional foods with additional biofunctional activity for human health as well as acceptability to consumers.

Oxidative stress in the human body can result from several types of reactive oxygen species (ROS), which are continuously produced as byproducts of aerobic metabolism (Biller and Takahashi, 2018; Bury et al., 2018). Some species of reactive oxygen are highly toxic, causing various diseases, and must be rapidly detoxified by antioxidants through various cellular mechanisms (Apel and Hirt, 2004; Eom et al., 2018).

The health benefits of dairy products have been known for a long time. In particular, many studies have revealed that cheese has antioxidant effects because it contains polyphenolic compounds (Branciari et al., 2015; Hilario et al., 2010). Some researchers have reported that the antioxidant effects that benefit health are due to the complexation between the phenolics and milk proteins (Park et al., 2018). However, this antioxidant activity is relatively weak due to low concentrations of polyphenolic compounds in cheese products.

Many researchers have studied the diversification of cheese products by adding various ingredients including herbs to increase biofunctionality (Lee et al., 2016). However, there is still no research on the effects of ginseng extract-supplemented quark cheese as a new cheese product.

In particular, quark cheese is a type of fresh dairy product manufactured by warming of soured milk until curdling, without aging. It is classified as fresh acid-set cheese and has a relatively soft texture. Traditionally, quark is processed as a dairy food in Northern European countries. Although quark cheese was originally manufactured without any protease, producers recently began adding small amounts of rennet. Many investigators have studied the physiochemical properties of quark cheese during its processing (Ferreiro et al., 2016).

Ginseng is a traditional medicinal plant used in Northeast Asian countries, particularly in Korea. Ginseng root extracts contain saponin, which is the major active ingredient and is known to have therapeutic activities against various diseases such as cancer, hypertension, and diabetes or to improve weak health (Jung and Jin, 1996). Many studies have reported the effects of red ginseng extract on cheese products such as camembert cheese (Choi et al., 2015; Lee and Bae, 2018), but the application of ginseng extract to quark cheese remains unclear.

Therefore, the aim of this study was to evaluate the physiochemical properties, changes in color and texture, sensory properties, and antioxidant effects of quark cheese supplemented with ginseng extract *in vitro*, as compared with regular quark cheese (control). Our hypothesis was that quark cheese with the added ginseng extract would have higher antioxidant concentrations as compared to controls. The results of this study can be practically applied by biofunctional-dairy-food manufacturers to help maintain public health.

Materials and Methods

Materials

Ginseng extract was obtained from Hwain Korea Co. (Seoul, Korea). The commercial starter was purchased from the New England Cheese-making Supply Co. (South Deerfield, MA, USA), whereas Man-Rogosa-Sharpe (MRS) agar was obtained from Difco Laboratories (Detroit, MI, USA).

Preparation of quark cheese

To prepare quark cheese supplemented with the ginseng extract, 5 L of pasteurized milk (Pasteur Milk Co., Ltd., Seoul, Korea) was supplemented with different concentrations of the ginseng extract (0%, 0.1%, 0.5%, or 1%). The commercial starter (*Streptococcus lactis* and *S. cremoris*) was inoculated at 0.002% (w/v) into milk samples mixed with the ginseng extract, and the mixture was incubated in a cheese vat (Sunil Instrument Co., Daejeon, Korea) at 35℃ for 220 min. After cultivation, rennet was added (0.2 mL/L), and the mixture was allowed to stand at 4℃ for 19 h for coagulation. The curds were packaged into sacks and allowed to stand for 18 h to drain out the remaining whey.

Enumeration of microbial cells

Samples from every stage of the cheese making process (inoculation, fermentation, cooling, and storage) were collected, and microbial growth was measured by the standard plate-counting method on MRS agar plates.

Physicochemical analysis

During fermentation, pH was determined with a pH meter (Inolab pH 720, Weihein, Germany). Proximate analyses of the contents of moisture, crude fat, protein, and lactose were performed by AOAC methods. The total solids, protein, fat, and ash contents were measured according to the methods of AOAC International (2000).

Antioxidant activity

Each cheese sample was added to twice its volume of methanol (cheese:methanol ratio of 1:2) and kept for 1 h at 30℃ in a shaking incubator (SI-900R, Jeio Tech, Kimpo, Korea), centrifuged at 1,900×g for 10 min (Combi-514R, Hanil Co., Ltd., Seoul, Korea), and passed through Whatman No. 2 filter paper. The filtrates were used as samples for the analysis of antioxidant activity.

Radical-scavenging activity was determined by a 2,2′-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS; Sigma, St. Louis, MO, USA) assay. We mixed 14 mM ABTS and 5 mM potassium persulfate in 0.1 M potassium phosphate buffer (pH 7.4) in a 1:1 ratio and incubated them for 16 h in a dark room at 25℃. The mixture was diluted with 0.1 M potassium phosphate buffer (pH 7.4) until the absorbance at 734 nm wavelength reached 0.7±0.02 on a spectrophotometer (X-ma 3200, Human Co., Ltd., Seoul, Korea). A 20 μL sample was then added to 980 μL of the above solution, and the mixture was incubated for 5 min in 37℃. Absorbance was measured at 734 nm. The antioxidant activity was calculated as follows:

$$\text{Antioxidant activity (\%)} = \left(1 - \frac{A_S}{A_C}\right) \times 100$$

A_c: absorbance values of the negative control

A_s: absorbance values of an experimental sample

Textural and color analysis

Texture profile analysis was performed using a TA-XT2 texture analyzer (Texture Technologies, Surrey, UK). Quark cheeses were prepared in a cube shape (30×30×30 mm) and tempered at 10℃. The textural analysis was carried out at room temperature. The data acquisition rate was 200 pps. The force threshold and contact force were 10 and 5 g, respectively, and the samples were compressed to 50% of their height. The P75 probe was employed, and the speed of the probe was 2.5 mm/s during the analysis. In terms of color, L*, a*, and b* values of each sample were determined with a chroma meter (CR-400 head, Konica Minolta, Tokyo, Japan).

Sensory analysis

Consumer sensory analysis was performed by 22 panelists (12 females, 10 males, age 26–30 years) who were screened according to accepted international standards (ISO 13299:2003). Quantitative descriptive analysis was performed to evaluate the differences in the sensory characteristics among ginseng-supplemented quark cheese samples (Ng et al., 2012). A continuous scale from 0 to 8 was used to measure the following characteristics: creamy odor, acid odor, ginseng odor, acid taste, bitter taste, aftertaste, and overall quality. Water and plain bread were provided between samples as a palette cleanser and quark cheese without the ginseng extract served as the reference standard.

Statistical analysis

The data were expressed as a mean±SD. For statistical comparisons, the results were subjected to one-way analysis of variance (at $p<0.05$) and Duncan's multiple-range test in IBM SPSS 22 software (IBM, Armonk, NY, USA).

Results and Discussion

Physicochemical analysis

The composition of cheese samples supplemented with different concentrations (0.1%, 0.5%, or 1.0%) of the ginseng extract is presented in Table 1. The concentration of solids in the ginseng extract was 61%±1.0% (w/v). The moisture content of ginseng extract-supplemented quark cheese was significantly lower than that of the control. Lee et al. (2016) reported that

Table 1. Physicochemical, color, and textural analysis of quark cheese supplemented with ginseng extract during cheese production as well as viable cell counts

Items		Ginseng extract concentration			
		Control	0.1%	0.5%	1.0%
Moisture (%, w/w)		$69.77±0.83^{a}$	$66.54±0.34^{b}$	$66.68±0.79^{b}$	$64.82±0.34^{c}$
Fat (%)		$1.63±0.26^{d}$	$3.20±0.07^{c}$	$6.36±0.32^{b}$	$9.90±0.04^{a}$
Protein (%)		$14.31±0.34^{b}$	$16.89±0.40^{ab}$	$16.94±0.22^{ab}$	$18.75±0.47^{a}$
Lactose (%)		$2.50±0.39^{a}$	$2.00±0.29^{a}$	$2.25±0.40^{a}$	$2.50±0.33^{a}$
Ash (%)		$2.08±0.08^{a}$	$2.06±0.06^{a}$	$2.04±0.05^{a}$	$1.93±0.09^{a}$
pH		4.41	4.30	4.37	4.44
Microorganisms (CFU/g)		$9.06±0.08^{a}$	$9.19±0.08^{a}$	$9.04±0.08^{a}$	$9.01±0.08^{a}$
Color	L*	$88.13±0.13^{a}$	$87.12±0.22^{b}$	$84.38±1.00^{c}$	$81.58±0.13^{d}$
	a*	$-1.48±0.07^{d}$	$-0.97±0.07^{c}$	$-0.09±0.02^{b}$	$0.55±0.04^{a}$
	b*	$6.09±0.13^{d}$	$7.52 ±0.10^{c}$	$11.06±0.04^{b}$	$14.23±0.10^{a}$
Texture	Springiness (mm)	$0.73±0.08^{a}$	$0.75±0.05^{a}$	$0.79±0.06^{a}$	$0.80±0.05^{a}$
	Gumminess (N)	$146.23±2.55^{d}$	$198.63±1.56^{c}$	$273.13±3.32^{b}$	$270.87±4.25^{a}$
	Cohesiveness	$0.35±0.13^{a}$	$0.47±0.14^{a}$	$0.35±0.14^{a}$	$0.41±0.12^{a}$
	Adhesiveness (N)	$285.82±7.98^{d}$	$416.05±3.25^{c}$	$484.09±5.89^{b}$	$568.61±9.95^{a}$
	Hardness (N)	$425.00±6.89^{d}$	$477.00±8.28^{c}$	$515.10±9.68^{b}$	$667.10±7.89^{a}$
	Chewiness (N)	$99.18±8.72^{d}$	$149.76±5.68^{c}$	$216.54±3.45^{b}$	$237.41±9.79^{a}$

$^{a–d}$ Means within a row with different superscript letters are significantly different, at $p<0.05$.
L* value (lightness), the shades from black (–) to white (+), a* value (redness), the hue from green (–) to red (+), b* value (yellowness), the hue from blue (–) to yellow (+).

this effect might be due to the influence of ginseng extract on the water-holding capacity of cheese. The ginseng extract, like *Inula britannica* extract, seemed to facilitate contraction of the cheese matrix by binding particles together and via expulsion of whey, thereby lowering the amount of entrapped water in the protein network. In addition, fat and protein contents were significantly increased by the addition of the ginseng extract. As for lactose and ash contents, these were not affected significantly by the addition of the ginseng extract at a concentration of less than 1.0% ($p>0.05$).

The ginseng extract did not significantly influence microbial counts of quark cheese ($p>0.05$). Kim et al. (2008) also reported that the addition of red ginseng extract to yogurt does not change lactic acid bacteria counts in the yogurt. At a concentration of less than 1.0%, the added glycoside-rich ginseng extract seemed to have no advantageous effects on the growth of lactic acid bacteria in our study.

In terms of the color parameters at different concentrations (0.1%, 0.5%, and 1.0%) of the ginseng extract in quark samples, L* values decreased significantly with the increasing concentration of the ginseng extract, while a* values significantly increased ($p<0.05$). b* values also increased with the increasing concentration of the ginseng extract. In this study, the dark brown color of the ginseng extract itself might have affected the color of the final quark cheese product. These results are supported by the study by Kim et al. (2008), who demonstrated that the addition of red ginseng extract to yogurt decreases L* values but increases b* values.

Changes in the texture profile of ginseng extract-supplemented quark cheese were assessed too. Regarding hardness, all the samples showed an increase with the increasing concentration of the ginseng extract (0.1% to 1.0%; $p<0.05$). This phenomenon may be due to the lower moisture content of ginseng extract-supplemented cheese. In all the samples, cohesiveness and springiness were measured and were found to range from 0.73 to 0.80 and from 0.35 to 0.41, respectively. However, the differences were not significant ($p>0.05$). Gumminess and chewiness significantly increased with the increasing concentration of ginseng extract. These results can be explained by the high hygroscopicity of ginseng extract. Song et al. (2007) reported that ginseng extract has high water-absorbing capacity and causes weakness of the dough of white bread.

Antioxidant activity

The ABTS assay is a standard method for measuring antioxidant activities (Yang et al., 2019). The radical of 2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid), i.e., $ABTS^{\bullet+}$, is produced via oxidation of ABTS by potassium persulfate. The mechanism of this assay is reduction of $ABTS^{\bullet+}$ in the presence of an antioxidant (Re et al., 1999). Some researchers have found that ginseng contains various antioxidant compounds (Chung et al., 2017). Fig. 1 depicts the results of ABTS radical-scavenging assays of ginseng extract-supplemented quark cheese. Increasing concentration of the ginseng extract caused a concomitant increase in the ABTS radical-scavenging activity ($r=0.803$, $p<0.01$). The ABTS radical-scavenging activities of the cheeses fortified with 0%, 0.5%, or 1.0% of the ginseng extract were 4.22%±0.12%, 20.14%±1.34%, and 56.32%±1.54%, respectively. This effect may be due to polyphenolic compounds such as flavonoids as well as various ginsenosides found in the ginseng extract (Chen et al., 2009; Jung et al., 2016; Ramesh et al., 2012).

Sensory evaluation

The sensory attributes of quark cheese supplemented with different concentrations (0.1%, 0.5%, or 1.0%) of the ginseng extract are presented in Fig. 2. The ginseng flavor and taste increased significantly with the increasing concentration of the ginseng extract in quark cheese ($p<0.05$). Flavor properties such as bitterness and ginseng odor significantly increased with the increasing concentration of the ginseng extract ($p<0.05$). In addition, the score of the aftertaste increased with the

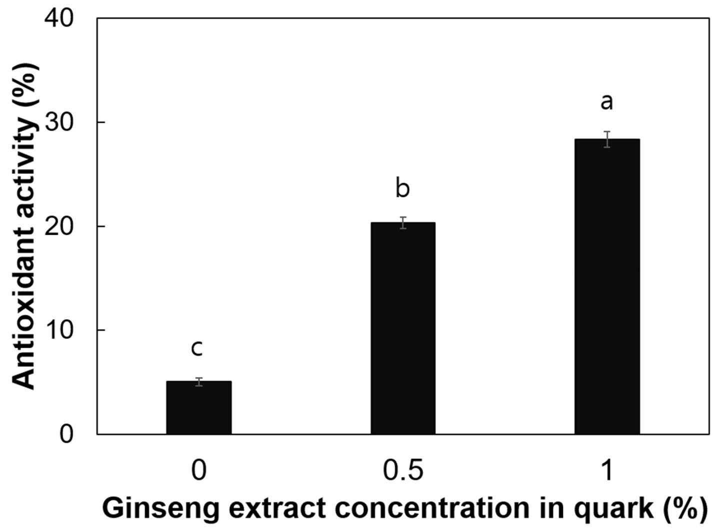

Fig. 1. ABTS radical-scavenging activity of quark cheese with different concentrations of ginseng extract. Bars with different lowercase letters are significantly different according to Duncan's multiple-range test (p<0.05). The formula for calculation of the percentages is given in materials and methods. ABTS, azino-bis-3-ethylbenzothiazoline-6-sulphonic acid.

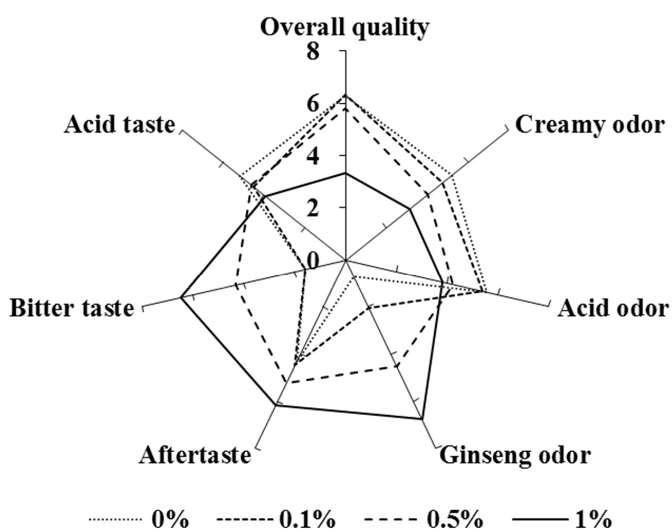

Fig. 2. The mean sensory intensity rating of ginseng-supplemented cheese. There were 22 judges. Each sensory attribute was tested in triplicate, and a quark cheese sample without the ginseng extract served as the reference standard.

concentration of the ginseng extract. In terms of total quality, there was no significant difference between the no-supplement control and the samples with less than 0.5% of added ginseng extract in quark cheese (p>0.05). Many researchers have noted that the addition of ginseng extract to other food products generally has negative sensory scores, despite the biofunctional activities of this ingredient toward human health (Lee et al., 2008; Lee et al., 2011). In contrast, our study revealed that the addition of the ginseng extract at a concentration of less than 0.5% did not significantly affect the total quality score.

Conclusion

This study was designed to develop ginseng extract-supplemented quark cheese and to evaluate its antioxidant effects (as possible benefits for human health), physicochemical changes (including color and texture), and sensory properties, as compared to a no-supplement control. The data on lactic acid bacterial counts, color, texture, and sensory evaluation from this study indicate that ginseng extract concentrations of 0.5% could be applicable to the development of quark cheese with biofunctional activities, such as antioxidant effects. It is known that ginseng extract contains various ginsenosides with biofunctional properties toward human health. In addition, some adult diseases are caused by oxidative stress in the human body. Therefore, ginseng extract-supplemented cheese products may help to maintain human health and prevent such diseases. Furthermore, the production of quark cheese that contains ginseng extract may broaden the applications of ginseng and increase the demand for cheese products.

Conflict of Interest

The authors declare no potential conflict of interest.

Author Contributions

Conceptualization: Eum SJ. Data curation: Hwang JE. Kim KT. Formal analysis: Eum SJ. Methodology: Eum SJ, Hwang JE. Software: Kim KT. Investigation: Paik HD. Writing - original draft: Kim KT. Writing - review & editing: Kim KT, Hwang JE, Eum SJ, Paik HD.

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