

EVALUATION OF FUNCTIONAL CEREAL BASED PRODUCT FORTIFIED WITH KOREAN RED GINSENG POWDER: A STUDY ON PHYSICOCHEMICAL AND ANTIOXIDANT PROPERTIES

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Abstract

Korean red ginseng is a renowned functional ingredient valued for its bioactive compounds and antioxidant potential. The purpose of Current stud was to evaluate the chemical, phytochemicals and physiochemical properties of red ginseng-based cereal developed by using different treatments. Firstly, proximate composition, mineral content, antioxidant activity, and bioactive compounds by Using HPLC of Korean red ginseng powder were analyzed. The results revealed $8.4 \pm 0.02\%$ moisture, $4.8 \pm 0.02\%$ ash, $12.2 \pm 0.02\%$ crude protein, $2.1 \pm 0.02\%$ crude fat, $7.3 \pm 0.02\%$ crude fiber, and 65% nitrogen-free extract. Mineral analysis showed calcium (368 ± 0.02 mg/100 g), iron (9.2 ± 0.02 mg/100 g), zinc (4.1 ± 0.02 mg/100 g), and magnesium. Antioxidant profiling demonstrated TPC (4.55 ± 0.11 mg GAE/g DW), TFC (2.82 ± 0.11 mg QE/g DW), FRAP (9.8 ± 0.36 mg TE/g DW), and DPPH activity ($62.44 \pm 0.12\%$). HPLC analysis identified ginsenoside Rb1 (24.6) as the predominant bioactive compound, indicating the sample's potential nutritional and functional properties. Afterward sensory evaluation was carried out to determine the most preferred cereal treatment was T1. The result showed that optimized cereal contained $5.82 \pm 0.02\%$ moisture, $9.34 \pm 0.02\%$ protein, $11.85 \pm 0.02\%$ fat, and $3.28 \pm 0.02\%$ fiber, with calcium as the predominant mineral (42 ± 1.56 mg/100 g). TPC, TFC and DPPH was Found (235.32 ± 0.02 mg), (56.97 ± 0.02 mg), ($8.89 \pm 0.02\%$) respectively. So the results conclude that these nutritional and antioxidant properties of red ginseng cereal can prevent the body from oxidative stress of free radicals that are linked to aging and many chronic diseases.

INTRODUCTION

Individuals have started to choose foods that are simple to prepare, nutritious and healthy, and are being used to cure a disease. In addition, as they keep themselves fit, they are letting their food selections be swayed by their limited time and overwork, as well as ready-to-eat foods. People are turning towards food that makes their day-to-day life easier because of the ongoing situation. The next step is from simple homemade food to functional food with a rich nutrient profile and with many antioxidants to resist the oxidative stress of the body, which is generally associated with a decrease in stress and protection of the body organs (Yoon et al., 2021).

The growing need for quick and easy-to-prepare foods and nutrient-rich products has inspired the production of functional foods with additional health-promoting benefits. Cereals are popular breakfast foods and are a good source of carbohydrates, dietary fiber, proteins, vitamins and minerals and are ideal for the incorporation of functional ingredients. Since ancient times, Korean red ginseng has been taken as tea,

supplements, and capsules. Ginseng's quick effects have made it a magical herb to ancient Korean and Chinese people. Korean red ginseng is referred to as red ginseng. It is obtained from the root of the *Panax ginseng* plant (Kim et al., 2022).

Korean red ginseng (KRG) is known for its health-promoting effects due to the presence of bioactive compounds like ginsenosides, phenolic compounds, and polysaccharides, which exhibit antioxidant properties. Although the study of KRG has been extensively done, there is still a lack of understanding about its optimized use in cereal-based products, especially in terms of nutritional, antioxidant, physicochemical, and sensory properties (Kim et al., 2024).

Materials and Methods

Collection and Processing of Raw Materials:

Korean red ginseng powder was purchased from the commercial platform Daraz, and the refined powder was stored in a clean, airtight polythene bag to protect it from any contamination.

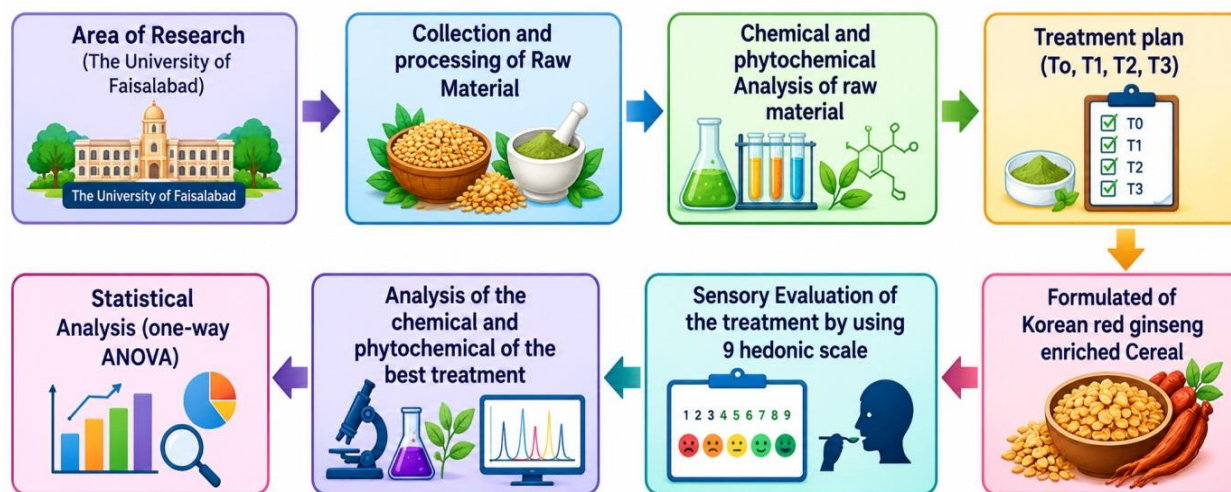


Figure1: Flow Chart of Red Ginseng formulated Functional Cereal

Chemical and Phytochemical Characterization of Korean Red Ginseng Powder

Korean red ginseng powder was analyzed for its proximate analysis, mineral analysis, and antioxidant profile activity. (Jaster et al., 2018).

Determination of Bioactive Compounds by Using HPLC

The bioactive compound profile was determined using HPLC through methanolic extraction. The phenolic content in the Korean red ginseng powder was determined by reverse-phase high-performance liquid chromatography by using this method (RP-HPLC) (Kim et al., 2022).

Preparation and Formulation of Korean Red Ginseng based Functional Cereal

Functional cereals were prepared by the incorporation of Korean red ginseng root powder

in a wheat-based cereal. Four treatments were prepared by using different levels of incorporation of red ginseng powder in which T_0 (control), T_1 was contained (5 g of Korean Red Ginseng powder per 100 g of formulation), T_2 (10 g), and T_3 (15 g) respectively. All ingredients of all treatments were mixed to make a formulated functional cereal by using this method (Rawat et al., 2023).

Treatment plan

The treatment plan was designed according to the formulations presented in Table 1.

Table 1: Treatment plan of Korean red ginseng cereal

Ingredients	T_0	T_1	T_2	T_3	The for mul ated Kor ean red gins eng
Wheat flour	78	73	68	63	
Brown sugar	10	10	10	10	
Butter	10	10	10	10	
Baking powder	2	2	2	2	
Korean red ginseng powder	0	5	10	15	
Total	100%	100%	100%	100%	

All dry ingredients, including wheat flour, brown sugar, baking powder, Korean red ginseng and butter, were weighed accurately and mixed thoroughly in a large mixing bowl to ensure uniform distribution and then baked and roasting was carried out in an oven at 150–160°C for approximately 20–25 minutes. During roasting, the mixture was stirred at regular intervals to prevent burning and to achieve uniform browning and a crisp texture.

Sensory Evaluation of Formulated Functional Cereal

After formulation, trained sensory panel evaluated the Korean Red Ginseng-enriched cereal samples using a 9-point hedonic scale (Maqbool et al., 2024).

Product Analysis

Chemical and Phytochemical Analysis of the best treatment of Functional Cereal

cereal was evaluated for proximate profile analysis, including mineral and Antioxidant activity (Stocco et al., 2019).

Fourier Transform Infrared Spectroscopy (FTIR)

An FTIR spectrometer was used to analyse Korean red ginseng root powder-enriched cereals, with wavelengths ranging from 400 to 4000 cm^{-1} . About 0.5 g of powder was mounted on the instrument and analysed, and the sample's spectra were obtained by using this reference (Erenstein et al., 2022).

Statistical Analysis

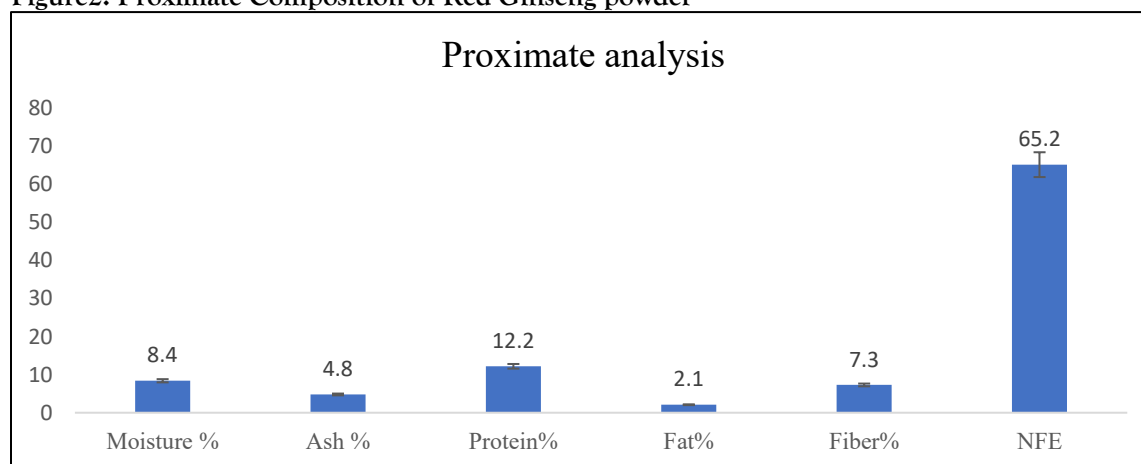
For determination of significance of the results obtained for each parameter was then subjected to statistical analysis using the Analysis of Variance Technique (ANOVA) (Park et al., 2023)

Results and Discussion

Results showed of Korean red ginseng powder and Korean red ginseng-enriched cereal are presented below. The proximate composition of Korean red ginseng powder was $8.4 \pm 0.02\%$

moisture, $4.8 \pm 0.02\%$ ash, $12.2 \pm 0.02\%$ crude protein, $2.1 \pm 0.02\%$ crude fat, and $7.3 \pm 0.02\%$ crude fiber; NFE (nitrogen-free extract) content was 65%

Figure2: Proximate Composition of Red Ginseng powder



Mineral Analysis of Korean Red Ginseng Powder

Mineral analysis of Korean red ginseng powder showed that calcium content was $368 \pm 0.02\text{mg}$, iron was $9.2 \pm 0.02\text{mg}$, zinc was $4.1 \pm 0.02\text{mg}$,

Table 2: Mineral Composition of Red Ginseng powder

Composition	Content mg/100g
Iron	9.2 ± 0.02
Calcium	368 ± 0.02
Zinc	4.1 ± 0.02

The results are expressed as mean $\pm$ standard deviation

Antioxidant Assay of Korean Red Ginseng Powder

Korean red ginseng powder showed an antioxidant profile with TPC 4.55 ± 0.11 mg GAE/g DW, TFC 2.82 ± 0.11 mg QE/g DW, FRAP 9.8 ± 0.36 mg TE/g DW and DPPH radical scavenging activity was found as high as $62.44 \pm 0.12\%$. DPPH value indicated good radical scavenging activity, and the presence of phenolic and flavonoid contents affirmed the

bioactive characterization of the powder.

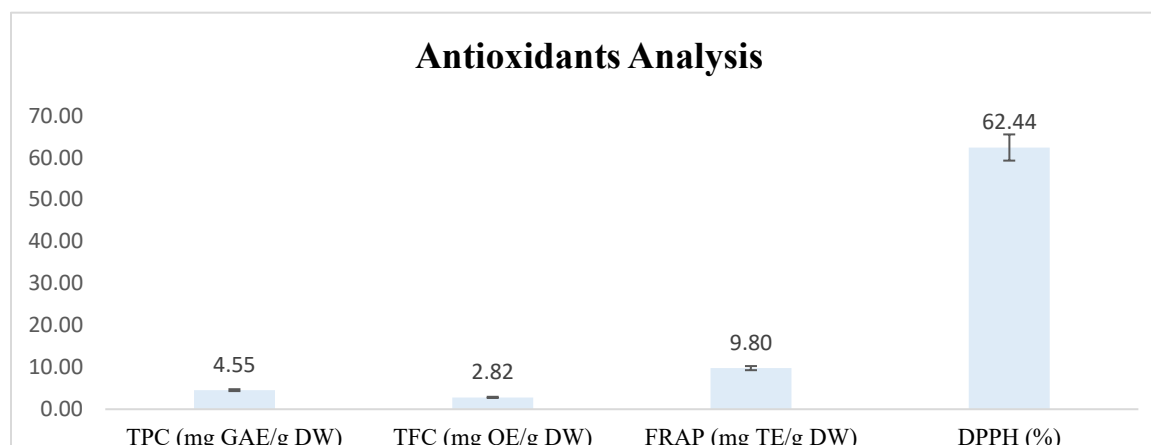


Figure 3: Antioxidant analysis of Korean Red Ginseng Powder

HPLC Profile of Korean Red Ginseng Powder

During HPLC analysis, many compounds were identified, with the highest concentration

recorded for ginsenoside Rb1 (24.6 mg/100 g DW) and the lowest for ferulic acid (7.2 mg/100 g DW).

Table 3: HPLC profile of Korean red ginseng

Peak No.	Compound	Retention Time (tR) min	Peak Area (%)	Concentration (mg/100 g DW)	k' Factor
1	Ginsenoside Rg1	6.42	12.4	18.5	3.28
2	Ginsenoside Re	8.13	10.6	14.2	4.42
3	Ginsenoside Rf	10.28	7.3	9.7	5.85
4	Ginsenoside Rb1	13.47	18.8	24.6	7.98
5	Ginsenoside Rc	15.11	13.7	17.8	9.07
6	Ginsenoside Rd	17.42	9.5	11.9	10.61
7	Maltol	19.63	20.2	21.4	12.09
8	Ferulic acid	22.31	7.5	7.2	13.87

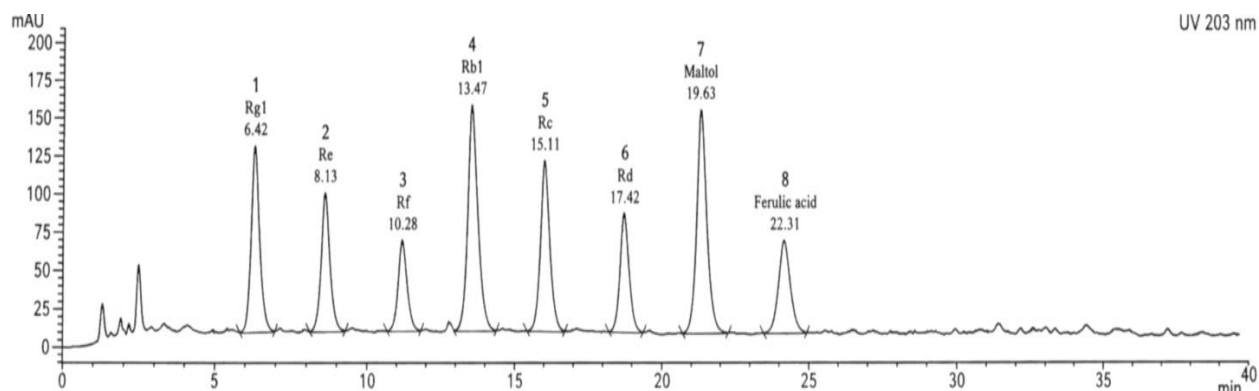


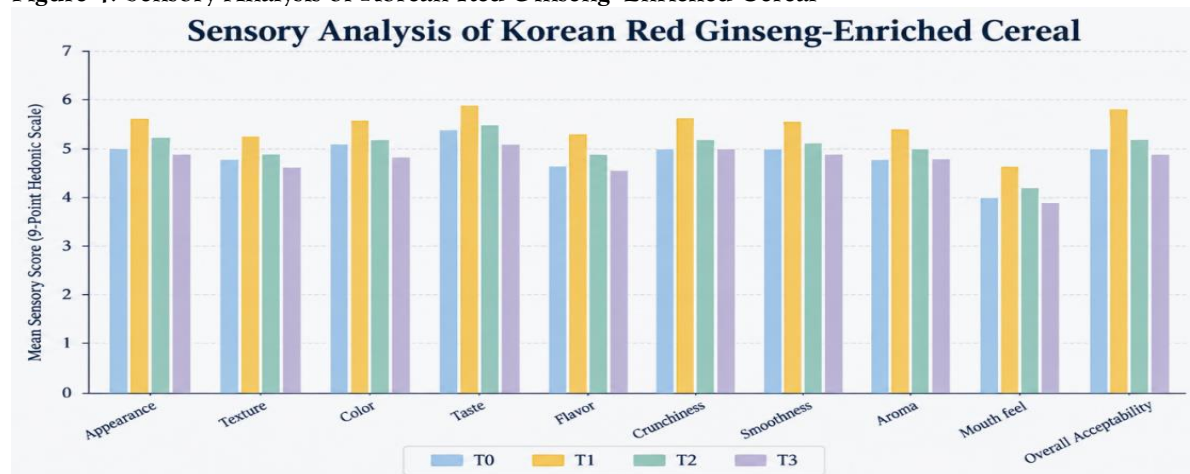
Figure 4 HPLC of Red Ginseng powder

Sensory Evaluation of Korean Red Ginseng-Enriched Cereal

Sensory evaluation was carried out by using a 9-point hedonic scale. Higher scores indicate

higher liking and better acceptability, which is T1 with best score acceptability.

Figure 4: Sensory Analysis of Korean Red Ginseng- Enriched Cereal



Proximate Composition of Best Cereal Treatment (T₁)

Proximate composition of the best cereal treatment was analyzed which showed the following results in which (moisture $5.82 \pm 0.02\%$, ash $1.96 \pm 0.02\%$, crude protein $9.34 \pm 0.02\%$, crude fat: $11.85 \pm 0.02\%$, crude fiber was $3.28 \pm 0.02\%$ respectively .

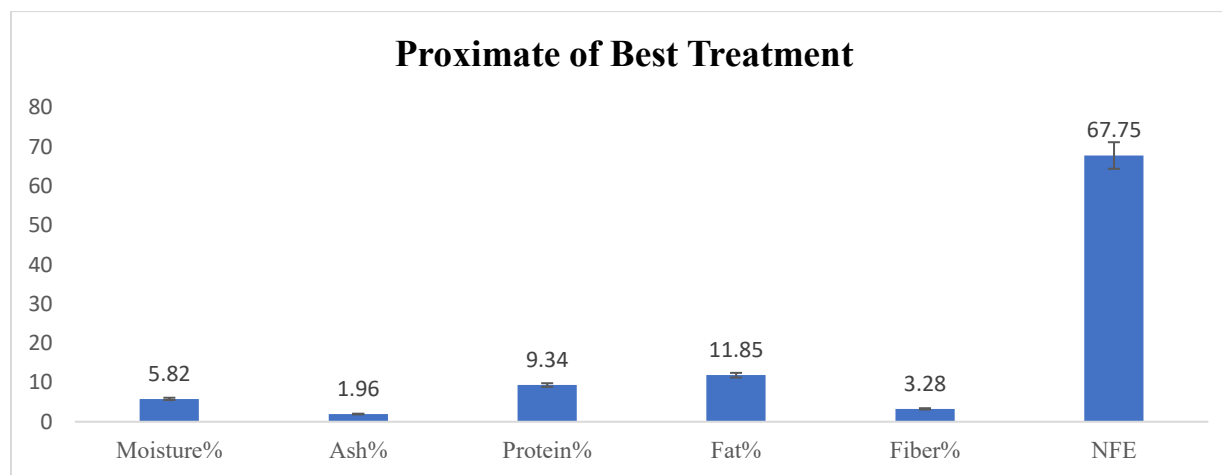


Figure5: Proximate analysis of Best Functional Cereal

Mineral Analysis of Best Functional Cereal Treatment

Mineral analysis of the best cereal treatment revealed appreciable levels of calcium (42 ± 1.56 mg/100 g), iron (4.8 ± 0.20 mg/100 g), and zinc

(2.6 ± 0.10 mg/100 g). Among the analyzed minerals, calcium exhibited the highest concentration, followed by iron and zinc, indicating the cereal's potential as a source of essential micronutrients.

Table4: Mineral Analysis of the best functional cereal treatment.

Composition	Content mg/100mg
Iron	4.8±0.2
Calcium	42±1.56
Zinc	2.6±0.1

Antioxidant Assay of Best functional Cereal Treatment

The best cereal treatment had an antioxidant assay as shown in the table. The high content of

total phenolics (TPC) and total flavonoid content (TFC) showed the presence of phenolic compounds in the selected cereal. The DPPH value indicates radical scavenging activity.

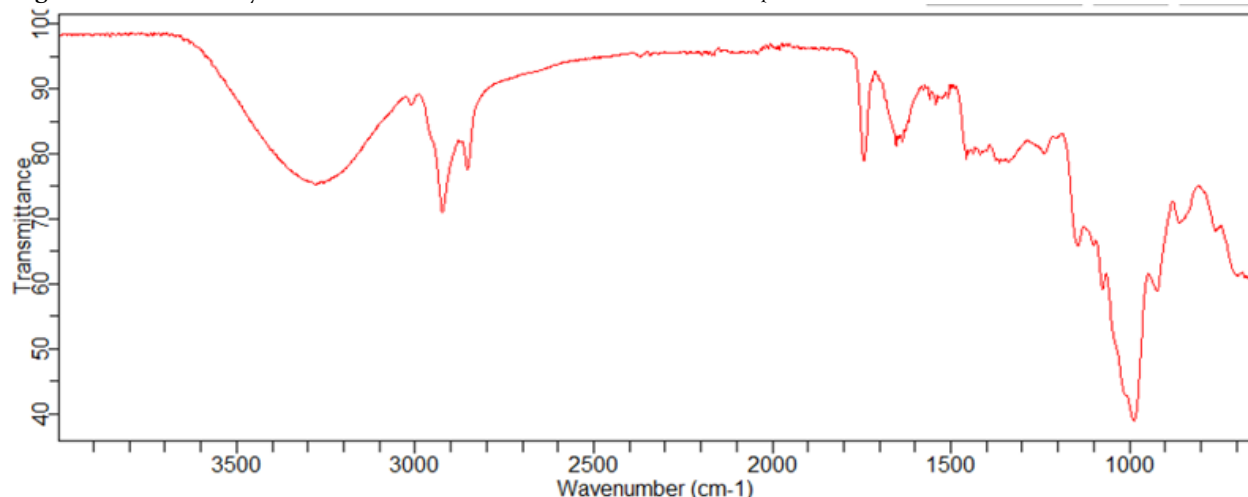
Table5: Antioxidant Assay of Best Cereal Treatment

Components	Concentration
TPC (mg GAE/g DW)	235.32±0.02
TFC (mg QE/g DW)	56.97±0.02
DPPH (%)	8.893±0.02
FRAP (mg TE/g DW)	61.71±0.47

FTIR Analysis of Korean Red Ginseng Root Cereal

The FTIR spectrum of Korean red ginseng root powder shows a broad absorption band at 3278.19 cm⁻¹, which is mainly due to O-H stretching vibrations. This confirms the presence

of hydroxyl-rich compounds such as polysaccharides, moisture, phenolic compounds, and glycosidic compounds. These are important because ginseng root contains carbohydrate-based materials and bioactive glycosides.

Figure 6: FTIR analysis of Best Functional Cereal Treatment T₁


Discussion

The results of the proximate analysis indicated that the Korean red ginseng powder contained a high level of carbohydrate content, moderate level of protein and fiber content, level of ash content. Polysaccharides and glycosidic compounds are naturally occurring in ginseng and could be responsible for the high NFE content. The polysaccharides, ginsenosides, phenolic compounds, flavonoids, and other bioactive metabolites found in Korean ginseng make it a promising functional food ingredient (Park et al., 2024). In addition, Korean red ginseng powder supplied important minerals to the cereal formulation, especially when added to wheat flour. Ginseng powder has been previously reported to have the ability to improve the nutritional and functional properties of food products as well as biscuits (Kwon et al., 2022; Mofor et al., 2023). The mineral content hence favors its use in value-added cereal products. Ginsenosides, phenolic compounds, flavonoids, polysaccharides, and other secondary metabolites in Korean red ginseng powder can be linked to its antioxidant activity. The DPPH activity of 62.44% confirms that there is significant free-radical-scavenging potential, similar to that reported earlier (Oh et al., 2025). The peak intensity of the HPLC analysis further verified the presence of ginsenosides Rg1, Re, Rf, Rb1, Rc, Rd, maltol, and ferulic acid with retention

times of 6.42–22.31 min, verifying the presence of the characteristic bioactive constituents of Korean red ginseng. Based on sensory evaluation, the formulation with T₁ (5 g Korean red ginseng powder/100 g formulation) had the highest overall acceptability. The higher the incorporation, the darker the colour, the stronger the bitterness, the rougher the texture and the deeper the herbal aroma with a higher incorporation rate, especially in T₃. Kwon et al. (2022) have described similar limitations with the sensory properties, and Lee et al. (2022) and Mofor et al. (2023) highlight optimization of ginseng-based products. The chosen cereal treatment had a good nutritional balance, with wheat flour and brown sugar contributing most of the NFE. Calcium was most abundant followed by Fe and Zn. Despite the dilution with the other ingredients, the final cereal still had nutritionally relevant minerals with lower concentrations than raw Korean red ginseng powder. Ginseng has been reported to be rich in nutritional and bioactive components, whereas mineral balance has been reported to be associated with ginseng quality and ginsenoside accumulation (Qian et al., 2024; Park et al., 2023). The cereal also showed significant TPC, TFC and DPPH activity, which suggests that antioxidant related constituents could have been retained in the cereal following the formulation. Kwon et al. (2022), Mofor et al. (2023), and

Wang et al. (2024) also observed similar enhancements in the antioxidant properties after the addition of ginseng. The FTIR spectrum of the cereal with Korean red ginseng showed functional groups of carbohydrates, proteins, lipids and other organic constituents. Major absorption regions included O-H stretching ($3200\text{--}3400\text{ cm}^{-1}$), C-H stretching ($2920\text{--}2850\text{ cm}^{-1}$), carbonyl-related vibrations ($1650\text{--}1750\text{ cm}^{-1}$), C-H bending ($1450\text{--}1350\text{ cm}^{-1}$), and C-O/C-C stretching ($1000\text{--}1200\text{ cm}^{-1}$), mainly associated with carbohydrate structures. The overall FTIR profile confirms the complex organic content of the developed cereal; however, FTIR is mainly useful for identifying functional groups, not individual compounds.

Conclusion

In the present study, a Korean Red Ginseng-enriched functional cereal was successfully developed and assessed as a convenient, nutritionally enhanced breakfast food. The addition of Korean Red Ginseng powder improved the functional and nutritional properties of the cereal, especially in terms of antioxidant capacity and bioactive compounds. The T1 (5% KRG) had the most desirable overall sensory acceptability in the developed formulations, with the added advantage of being an enriched formulation with KRG. The results reveal that it is feasible to include KRG (Korean Red Ginseng) at an acceptable level in cereal products without affecting consumer acceptability. Hence, the cereal enriched with KRG has potential as a functional food product with nutritional value, antioxidant activity, and convenience.

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