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Research Article

Utilization of Garlic Extract for Confectionery Products

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ABSTRACT

Garlic contains significant amounts of amino acids and sulfur compounds that can improve immune system against viruses responsible for colds. The current research is intended to evaluate the effects of garlic extract having antioxidant properties on the formation of confectionery products (lozenges and gummies). The products' quality depended highly on concentration of garlic extract, sugar and flavoring agent. The percent composition of the sugar, flavoring agent and garlic extract for product lozenges were 100:0:0 for T0, 75:20:5 for T1, 75:15:10 for T2 and 75:10:15 for T3. And the percentage composition of sugar, gelatin, flavoring agent and garlic extract for product gummies were 100:0:0:0 for T0, 55:20:20:5 for T1, 55:20:15:10 for T2 and 55:20:10:15 for T3. Proximate analysis, antioxidant activity, color, pH and minerals of the sample were calculated. The results of the proximate analysis of the best lozenge sample were 32.03% moisture, 2.01% crude fat, 5.31% protein, 2.4% fiber, 2.6% ash, 30.98% DPPH, 35.56% NFE and pH were 7.0. And the results of the best gummies sample were 36.6% moisture, 1.33% crude fat, 10.09% protein, 1.5% fiber, 2.4% ash, 31.81% DPPH, 36.35.64% NFE and pH were 7.0. The mineral composition of the best one lozenge sample was 6.8 mg/l iron, 20.98 mg/l calcium and 1.23 mg/l zinc and the mineral composition of the best one gummy sample were 3.13 mg/l iron, 21.78 mg/l calcium and 3.08 mg/l zinc. With reference to sensory evaluation T2 was most preferred for lozenges and T3 for gummies. These results indicate that using garlic extract in formation of confectionery products may help to improve oral health.



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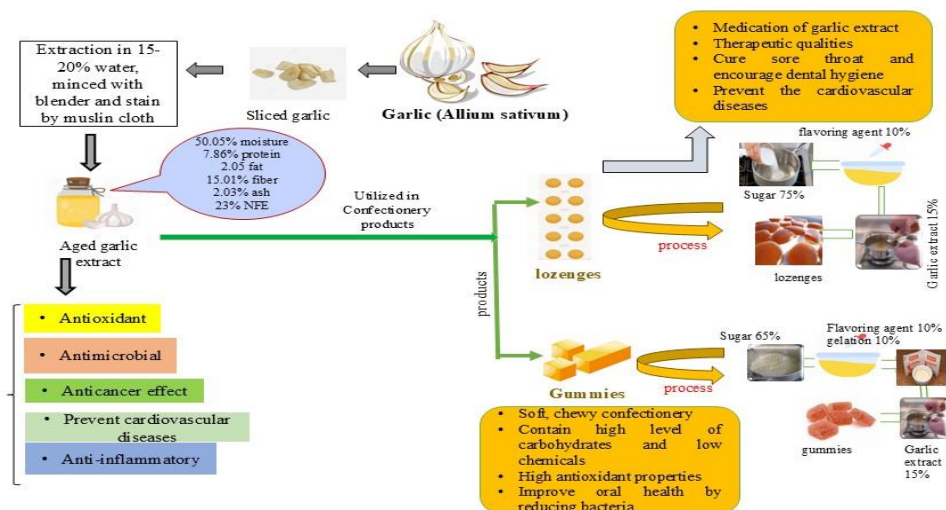
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Keywords: Garlic extract, Antioxidant, Confectionery, Oral Health.

INTRODUCTION

Garlic has been found and used in Greek and Egyptian temples since the beginning of recorded history. Its advantages for traditional medicine and culinary flavoring were known to the ancient Egyptians. Moreover, garlic is among the earliest documented uses to avoid disease and maintain health. About twenty-five years ago, Hippocrates, known as the Father of Medicine, declared, "Let food be thy medicine and let medicine be thy food." Hippocrates, who suggested the garlic for a number of illnesses, supports this claim. Garlic was offered to laborers in a number of cultures to fortify and increase their productivity. The bulbous plant known as garlic (*Allium sativum* L.), is a member of the Liliaceae family, originated in central Asia and is now farmed in many different countries across the world (De Gareef *et al.*, 2021).

Garlic is used medicinally in the form of powder, oil, and pills. Currently, efforts are being made to find incredibly efficient methods to remove active ingredients from various fruits and vegetables. Studies have indicated that the biological properties and quantity of bioactive compounds in fruits and vegetables are influenced by the kind of solvent employed and the extraction technique (Zhang *et al.*, 2020).

Zhang *et al.*, (2020) states that 60–65% of garlic is made up of the water, 28–30% carbohydrates, ~2.3% compounds of organosulfur, 2–6% of proteins, ~1.2% of amino acids, and ~1.5% of fiber, phenols, fatty acids, and trace amount of minerals. Garlic has high quantities of phosphorus, zinc, sulfur and the potassium, and modest amount of the calcium, selenium, iron, manganese and the magnesium, and lowest range of the vitamin A, C, B complex and sodium. Garlic that is intact typically includes some bioactive compounds, but when it is diced or crushed, a number of chemical processes have been demonstrated to produce more molecules, including as allicin, DAS, DADS, dithiins, and ajoene (Dziri *et al.*, 2012).

According to Nantz, garlic is a rich source of amino acids and sulfur compounds to enhance the capacity of immune system to combat viruses, particularly those that cause colds. In this situation, garlic has proven to have potent anti-inflammatory qualities by reducing inflammatory biomarkers in adult patients suffering from end-stage renal disease (Zare *et al.*, 2019). Garlic supplementation also increased microbial richness and improved the state of inflammation in people with uncontrolled hypertension (Ried *et al.*, 2018). The antioxidant properties of AGE garlic extract and the high bioavailability of SAC and SAMC, which are swiftly absorbed by the digestive tract, seem to be important components in the biological actions of garlic (Zhang *et al.*, 2020).

Lozenges are flavored, mouth-held dose forms with a sweetened base that are supposed to be sucked into. For those who are unable to take solid oral dose forms, lozenges are a gentle way to keep an even level of active ingredient in the oral cavity (Choursiya *et al.*, 2020). The development of innovative drug delivery techniques for pharmaceuticals that are already licensed and that offer the following benefits: higher bioavailability, less dose requirements, avoidance of first-pass hepatic metabolism, and water ingestion (Shivani *et al.*, 2020). Gummies are among the most popular candies and are excellent for product design. Consumers like them because of their distinct gummy feel and variety of eye-catching hues, smells, and shapes. They include botanical extracts (like garlic extract), sweeteners, and additional flavorings and colorings (Gunes *et al.*, 2022). GCs showed antibacterial action against *Salmonella enterica*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Streptococcus mutans*, *Proteus mirabilis*, and *Staphylococcus aureus*, among other hazardous bacteria. Garlic extract is a workable way to alleviate the low nutritional profile of this confection by adding healthier substitute components to GCs (Tarahi *et al.*, 2023).

The objective of this study was to evaluate the effects of the garlic extract having antioxidant properties on the formation of confectionery products (lozenges and gummies).

MATERIALS AND METHODS

Collection of Materials

The materials that were used for this research included garlic, sugar, flavoring agent (lemon mint) and gelatin that purchased from local market of Multan. All collected raw material were transported to the Department of Food Science and Technology Laboratory, MNS-University of Agriculture Multan.

Extraction of the Garlic Extract

For the process of extraction of garlic extract, the garlic were peeled, cleaned and washed. Blender was used for mincing the garlic and water was used as solvent for extraction. Garlic mixture was strained with muslin cloth. It was stored at room temperature till further use in product formation. Garlic extract was subjected to proximate assessment (moisture, crude fat, crude protein, crude fiber, ash), according to the procedure of Frankel *et al.*, (2016) as shown in figure 1.



Figure 1. Extraction process of garlic extracts from garlic cloves.

Proximate Analysis of Garlic Extract

The mean value of proximate analysis of garlic extract was given in figure 2. The proximate analysis such as moisture content, crude fat, crude protein, the percentage of fiber content and ash content of raw material (garlic extract) were determined by the method given in AOAC (2019). The moisture percentage of the garlic extract was 50.05 ± 1.00 , the crude protein value was 7.86 ± 0.48 , the crude fat percentage was 2.05 ± 0.01 , the crude fiber content was 15.01 ± 0.06 , ash percentage was 2.03 ± 0.8 and NFE percentage was 23 ± 2.03 .

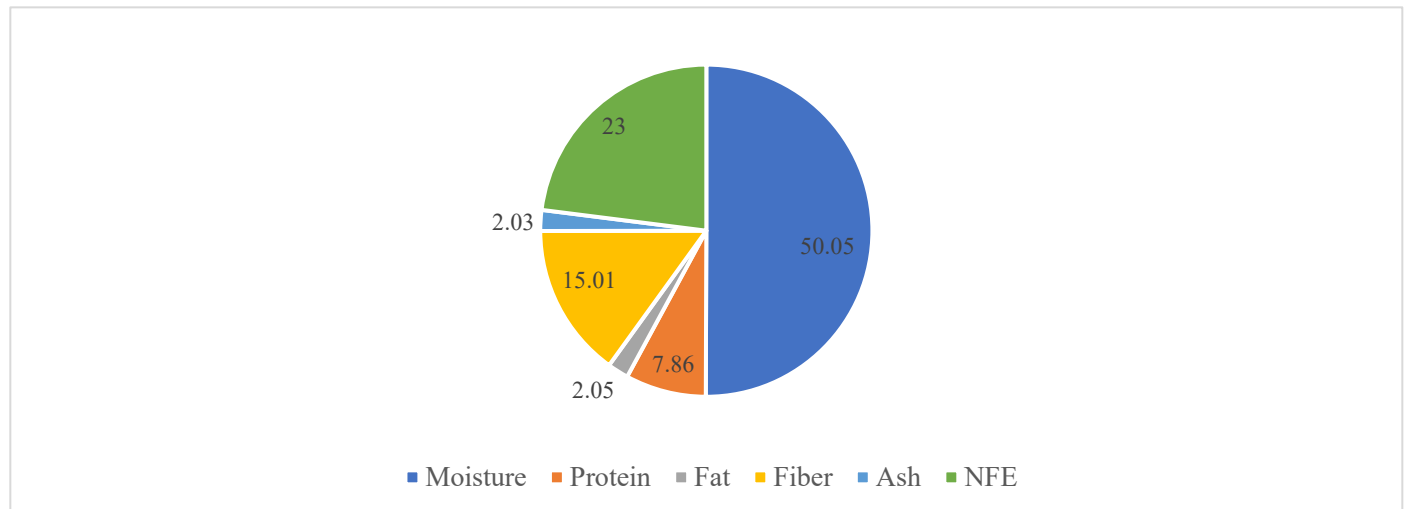


Figure 2. Proximate composition of garlic extract.

Formation of Lozenges

The lozenges containing garlic extract were prepared. The sugar (100%, 75%, 75% and 75%) was mixed with garlic extract (0%, 5%, 10% and 15%) and flavoring agent (0%, 20%, 15% and 10%) in various combinations as presented in table 1. The mixture was heated while stirring continuously. After few minutes, it was removed from heat and then placed in lozenges shaped candies. Lozenges were mixed in some cornstarch or powdered sugar to prevent sticking. Cooled these lozenges at room temperature (25°C) and stored in a dry place to harden until further analysis by Popli *et al.* (2025) as shown in figure 3.

Treatment plan

Table 1. Treatments using different proportions of flavoring agent and garlic extract

Treatments	Sugar %	Flavoring agent %	Garlic extract %
T ₀	100%	0%	0%
T ₁	75%	20%	5%
T ₂	75%	15%	10%
T ₃	75%	10%	15%

Flow Diagram

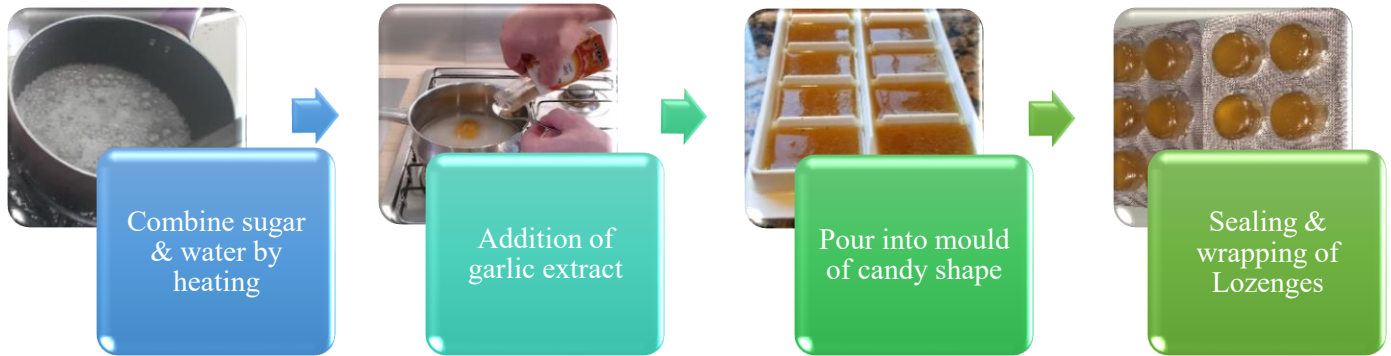


Figure 3. Flow diagram showing formation of Lozenges.

Formation of Gummies

Garlic extract was used in the preparation of gummies. The sugar (100%, 55%, 55% and 55%) was mixed with garlic extract (0%, 5%, 10% and 15%), gelatin (0%, 20%, 20% and 20%) and flavoring agent (0%, 20%, 15% and 10%) in various combination as presented in table 2 and the mixture were heated at 50°C, while stirring continuously. When mixture was completely heated, it was put into gummy molds and the gummies were stored in an airtight container to keep fresh until further analysis by Chuensun and Intipunya, (2025) as shown in figure 4.

Treatment plan

Table 2. Treatments using different proportions of flavoring agent and garlic extract

Treatments	Sugar %	Gelatin %	Flavoring agent %	Garlic extract %
T ₀	100%	0%	0%	0%
T ₁	55%	20%	20%	5%
T ₂	55%	20%	15%	10%
T ₃	55%	20%	10%	15%

Flow Diagram



Figure 4. Flow diagram shows formation of Gummies.

Chemical Composition

The chemical composition (the crude fat, the moisture percentage, crude protein, crude fiber and the value of ash) of the product (lozenges and gummies) were determined as described in AOAC (2016). The color (L^* , a^* and b^* value) of the products, lozenges and gummies was determined with colorimeter. A texture analyzer may be used to quantify texture using an instrumental technique like texture profile analysis (TPA) with evaluated properties including stickiness, cohesion, chewiness, elasticity and hardness. pH meter was used for determination of pH of the samples. The antioxidant property of the lozenges and gummies was observed by implanting DPPH (1, 2-Diphenyl-2-picrylhydrazyl) assay method. A DPPH solution was prepared by dissolving 4.3 mg of DPPH (1, 2-Diphenyl-2-picrylhydrazyl) in 3.3 μL of methanol.

Mineral Concentration

The mineral concentration such as calcium of the products (lozenges and gummies) was determined by using flame atomic absorption spectrophotometry (FAAS) while iron and zinc analyzed by the atomic absorption spectrophotometer instrument following the method by 999.11 described in AOAC (2016). One gram of the product specimen was added into a 100 ml of beaker to determine its minerals content. HNO_3 of 7 ml was added to the beaker and the sample was allowed to stay overnight. The sample was collected, along with 3 ml of HClO_4 and placed on a hot plate for digestion at a temperature of around 180°C . When roughly 2-3 ml of the sample remained, the hot plate was turned off. The beaker was removed from the hot plate and given some time to cool. After cooling the sample, the volume was made with 100 ml of distilled water. This process of dilution was performed with addition of 100 ml of distilled water as shown in figure 5.

The percentage of moisture in lozenges and gummies was estimated by using oven drying. The crude protein content was assessed with the help of Kjeldhal apparatus. The percentage of crude fat was estimated with the help of soxhlet apparatus. Determination of fiber was done by using hot plate (AOAC, 2016). For an objective of color assessment (L^* , a^* and b^*) colorimeter were used. A texture analyzer was used to quantify texture using an instrumental technique like texture profile analysis (TPA) which evaluated properties including stickiness, cohesion, chewiness, elasticity and hardness. The free radical scavenging activity was measured using a spectrophotometer as method described by Godara *et al.*, (2020). The sensory evaluation was done in sensory evaluation lab to determine the aroma, overall appearance, texture, taste and the general acceptability.



Figure 5. Proximate analysis (moisture, crude fat, crude protein, pH), phytochemical analysis such as mineral analysis, texture analysis, color measurement and sensory evaluation of the products (lozenges and gummies).

4. Phytochemical Analysis

Antioxidant Activity

The antioxidant activity of the products (lozenges and gummies) was determined by using the DPPH (1, 2-Diphenyl-2-picrylhydrazyl) assay method. A DPPH solution was prepared by dissolving 4.3 milligram amount of DPPH (1, 2-Diphenyl-2-picrylhydrazyl) in the 3.3 microliter of the methanol. Using methanol, the sample volume was increased to 150 μ L, after which 3 L of each sample was further diluted and combined with 150 μ L of the DPPH solution (Hanna *et al.*, 2023).

The Scavenging effect of DPPH (%inhibition) – $(Ac-As) / As \times 100$

Ac= The absorbance of control

As= The sample absorbance

Color Measurement

For an objective of color assessment (L^* , a^* and b^*), each lozenge and gummies sample were homogenized in two of 2.54 centimeter of deep fillet samples. Putting each sample below the colorimeter's color sensor allowed for the recording of readings for L^* , a^* and b^* . Reading of " L^* " were obtained in the range of 0 to 100, illustrating the samples lightness and darkness. If " a^* " has positive results red color will be indicated and if " a^* " has negative results green color will appear. When " b^* " has positive value blue shading is shown and in case of negative value yellow shading is presented. Inspecting of " b^* " is related to the yellow and blue shading (Paternina *et al.*, 2022).

Sensory Evaluation

The sensory evaluation was done in the sensory evaluation lab of the Department of Food Science and Technology, MNS-University of Agriculture Multan. The trained tasting panel consisted of ten people who took part in the sensory analysis. Ten samples of lozenges and gummies were tagged and given to a sensory panel to determine the degree of resemblance regarding the aroma, overall appearance, texture, taste and the general acceptability. Water was provided to panelists between samples so they could fully remove and neutralize any lingering flavors. All samples were served in one time use dishes. A hedonic scale of 1 (dislike extremely) to 9 (like extremely) with 9 being the highest score was employed (Lawless and Heymann, 2010).

Statistical Analysis

With the aid of the statistical programme STATISTIX (version 8.1) all the collected data were analyzed. In accordance with the recommended technique, the level of significance in between the treatments was obtained by applying the one-way factorial design ANOVA (analysis of variance) proceeded with the test of turkey. The resulting information was calculated for lettering.

RESULTS and DISCUSSION

Proximate Analysis of Garlic Extract

The proximate results of the raw material (garlic extract) were given in figure 2. Water is an important transport component for most biochemical reactions. The food samples which have water content of up to 12% generally have short shelf life (Mercy, 2015). Existing research indicates that garlic extract contains 50.05% moisture. The current findings of the moisture content in garlic extract were in collaboration with Rasul suleria *et al.* (2015). According to their results, moisture content in garlic extract was 65% and 68%. Similar results are also stated by Sajid *et al.* (2014). The main amino acids that are required in the body are supplied by the protein. According to current research, percentage of crude protein in garlic extract was 7.86%. The current results of crude protein content were linked with the results Otunola *et al.* (2010). According to their findings, crude protein content in garlic extract was 7.87% and 7.05%. The dietary fibers are usually scattered polysaccharides that cannot be assimilated by the enzymes of human digestive system (Madsen *et al.*, 2000). Because of this, fiber plays a vital part in the prevention of hyperglycemia. According to research, crude fiber content of garlic extract was 15.01%. The high-fat contents indicate the maximum caloric percentage and the achievable existence of the fat-soluble vitamins, specifically the vitamins D, A, K and E. The crude fat content of garlic extract was calculated as 2.05%. The current findings of crude fat content were in collaboration with Gorinstein *et al.* (2008). According to their results, crude fat content in garlic extract was 0.1-0.2%. The total mineral content is determined by the ash content. The current findings regarding ash content of garlic extract were 2.03% and these findings are in correspondence with results of Dalhat *et al.*, (2017) and Sampath *et al.* (2010) who confirmed the amount of the ash content as 1.44% and 1.32%. The determination of Nitrogen-Free Extract (NFE) in a

sample includes calculating the carbohydrates content by difference. After conducting the proximate analysis of garlic extract, the nitrogen free extract of the garlic extract was found between 20.33 to 24.3%. The current findings of nitrogen free extract were in collaboration with Otunola *et al.*, (2010), who confirmed the amount of the nitrogen free extract as 21.5%.

Proximate Composition of Lozenges Sample

Figure 6 shows the chemical parameters of the developed lozenges from garlic extract which includes: fat, moisture, fiber, protein, NFE, pH and ash. The moisture contents ranged from 2.05% to 53.28% in lozenges sample. The results were comparable with commercially produced lozenges with a moisture content of 51.03% to 53.28% on average. The moisture content of lozenges was resembled with the study of Kadirvel *et al.* (2022) and Gopale *et al.* (2022). The fat percentage of lozenges ranged from 1.73% to 2.01%, the results were comparable with commercially produced lozenges with a fat content of 2.33% to 2.52%. The study of variance of fat value of the lozenges showed the non-significant results. The results of present research were in correspondence with Rathod *et al.* (2018). The crude protein ratio in the lozenge product ranged from 0.20% to 5.4%. The results are comparable with commercially produced lozenges with a protein percentage of 4.23% to 5.31%. The analysis of variance of protein contents of lozenges made by utilization of garlic extract showed the highly significant results ($p \leq 0.01$). The protein content of lozenges was compared with the study of Kadirvel *et al.* (2022). The crude fiber contents in the lozenge product ranged from 1.02% to 2.64%. The results are comparable with commercially produced lozenges with a crude fiber percentage of 3.6% to 5.2%. The ash contents in the lozenge product ranged from 2.33% to 2.6% according to figure 6. The highest ash content in lozenges product showed the high level of minerals content such as iron, calcium and potassium. The results of current research correlated with the work of Rathod *et al.* (2018). The NFE value of lozenges ranged from 99.56 to 36.35 among the samples. The pH value of all sample of lozenge product ranged from 5.65% to 7%. The analysis of variance of lozenges showed the highly significant difference. The results were comparable with commercially produced lozenges with a pH content of 2.65% to 3.77%. Results were in correspondence with Kadirvel *et al.* (2022).

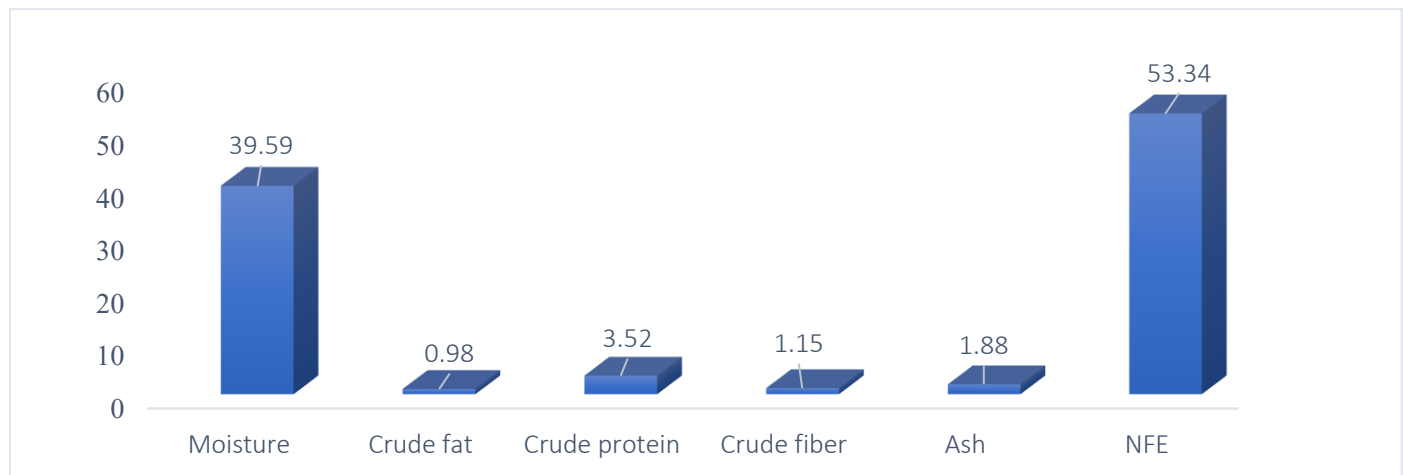


Figure 6. Mean of proximate analysis (moisture, crude fat, protein, fiber) of lozenges.

Proximate Composition of Gummies Sample

Figure 7 shows the chemical parameters of the developed gummies from garlic extract. The moisture contents ranged from 0.03% to 36.6% in the gummies sample. The ratio of gummies moisture was compared with the study of Lohar *et al.* (2020). The crude fat content of gummies sample varied from 0.3% to 1.33%. The results were comparable with commercially produced gummies with a fat percentage of 0.04% to 0.18%. The results of present research were in resemblance to Lohar *et al.* (2020). The protein contents in the gummy product ranged from 0.02% to 10.09%. The results are little higher than commercially produced lozenges with a protein percentage of 4.06% to 5.01%, this could be due to higher content of garlic extract. The protein content of products was compared with the study of Jamir and Sibain, 2023. The crude fiber content in the gummy product ranged from 0.23% to 1.5%. The results are comparable with commercially produced lozenges with a crude fiber percentage of 3.6% to 5.2%. The study gives the comparability with the investigation of Lohar *et al.* (2020). The ratio of crude ash in the gummy product varied from 0.3% to 2.4% according to figure 6. The processing parameters shows a highly remarkable variation in the ash content of gummies.

The NFE value of gummies ranged from 99.64% to 48.08% among the gummies product. The pH value of all sample of gummy product categorized from 5.3% to 7%. The results showed differences with commercially produced gummies with a pH content of 4.51% to 4.93%, this could be due to garlic extract which has little higher pH. Results were comparable but having little difference with Lohar *et al.* (2020).

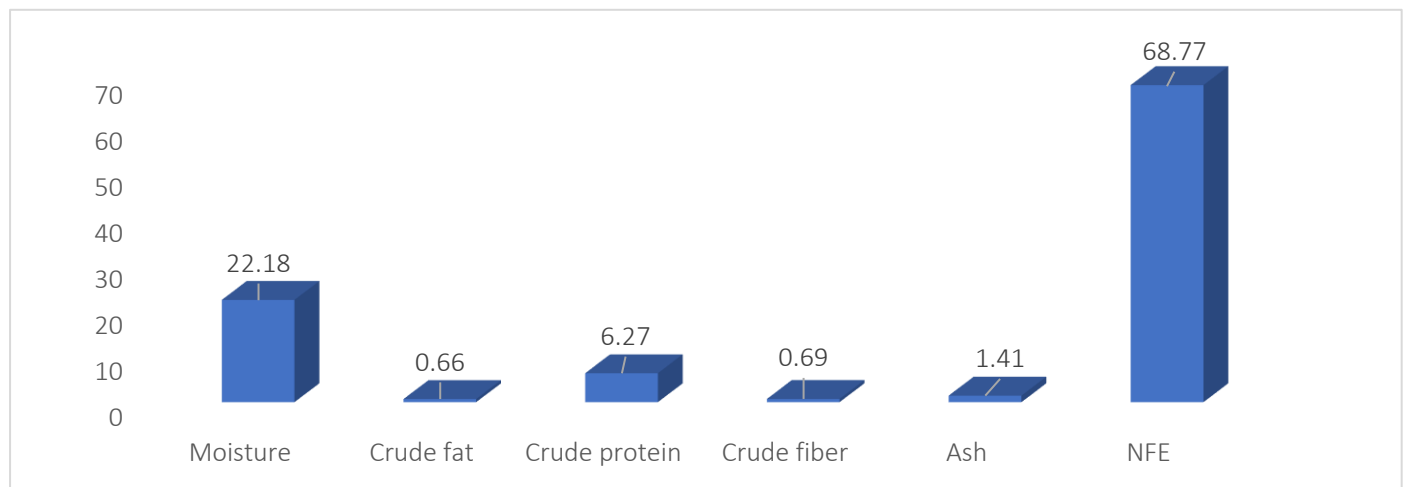


Figure 7. Mean value of proximate analysis (moisture, crude fat, protein, fiber) of gummies.

Effect of Garlic Extract on Mineral composition of Lozenges and Gummies

Figure 8 shows the mineral composition of the developed lozenges and gummies from garlic extract. The mineral profile indicates the occurrence of essential components of mineral include the iron (4.62mg/100g), calcium (16.77mg/100g) and zinc (0.76mg/100g) in lozenges and, mineral composition in gummies such as iron (1.73mg/100g), calcium (16.94mg/100g) and zinc (1.72mg/100g). Iron enhances the elements of the cytochromes, and the transfer of electrons, activates few enzymes, and involves chlorophyll formation. The percentage of iron in T₃ sample (6.80) was higher than other samples. The calcium used in the origination and steadiness of the cell walls and is involved in building of membrane permeability, regulates few enzymes, control some reaction of the cells to the stimuli. The percentage of calcium in the T₃ sample (20.98) was higher than other samples. Zinc content of T₃ sample (1.23±0.01) was higher than other samples in lozenges. It was expected that the range of the results should be stated and not absolute values. As shown in table 8 there was a remarkable ($p \leq 0.05$) variation in the value of iron in all samples. The results of my study correlated to the findings of Haciseferogullari *et al.* (2005) and with the study of Nazir *et al.* (2022). Iron content of T₃ sample (3.13±0.01) was higher than other samples. Calcium content of T₃ sample (21.78±0.03) was higher than other gummies sample. Zinc content of T₃(3.08±0.05) was higher than other gummies sample. The results are highly significant according to analysis of variance (ANOVA). The efforts done by Haciseferogullari *et al.* (2005) and the experiment of Nazir *et al.* (2022) also give the results close to the current findings.

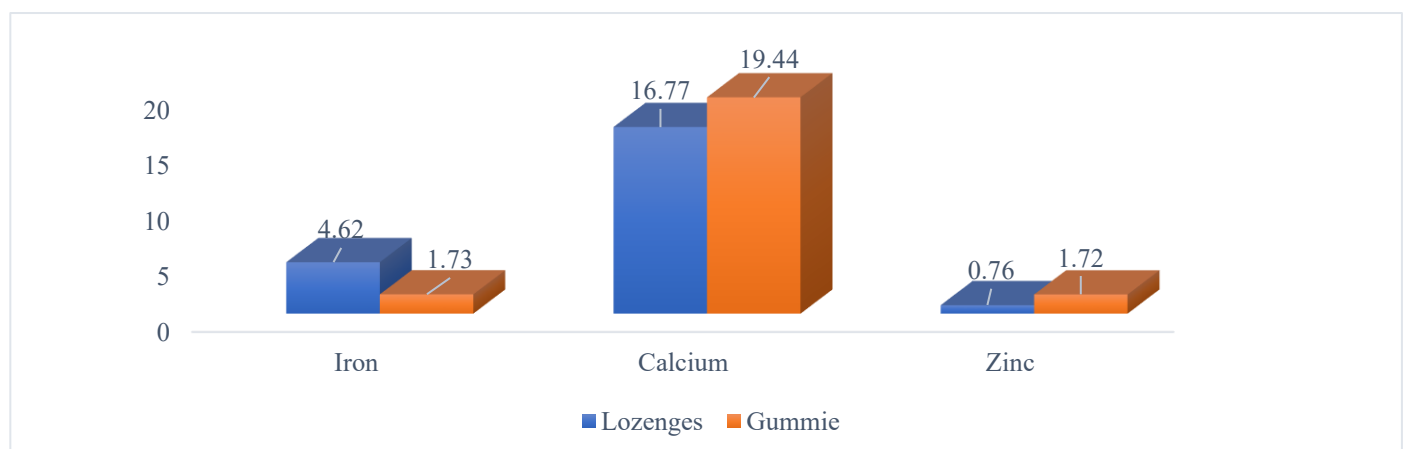


Figure 8. Mean values of mineral composition (iron, calcium, zinc) of lozenges and gummies.

Effect of Garlic Extract on Color of Lozenges and Gummies

One of the dominant factors that determine the user's food preferences is color. The outer presence of the product especially emerging from the color is of main priority. Figure 9 shows the garlic extract impact on the color composition of the lozenges and gummies. The analysis of variance of parameter L^* , a^* and b^* value of lozenges prepared from the extract of garlic showed highly significant difference. The lozenges prepared from treatment T_2 (15% flavoring agent and 10% garlic extract) showed the highest value of L^* and the lozenges prepared from treatment T_3 (20% flavoring agent and 5% garlic extract) showed the lowest value of L^* . The lozenges prepared from treatment T_1 showed the highest value of a^* and the lozenges prepared from treatment T_0 showed the lowest value of a^* as shown in table 9. The lozenges prepared from treatment T_0 (100% sugar) showed the lowest value of b^* and the lozenges prepared from treatment T_1 (20% flavoring agent and 5% garlic extract) showed the highest value of b^* . It was observed in this study that the color factors caused a significant minimization in ranges which were assumed due to the thermal declination during the consideration of heat, illumination, oxygen matter and storage conditions. These findings were compared with the work of Lohar *et al.* (2020) based on their color analysis. Another study done by Lucas *et al.* (2018) has the same results.

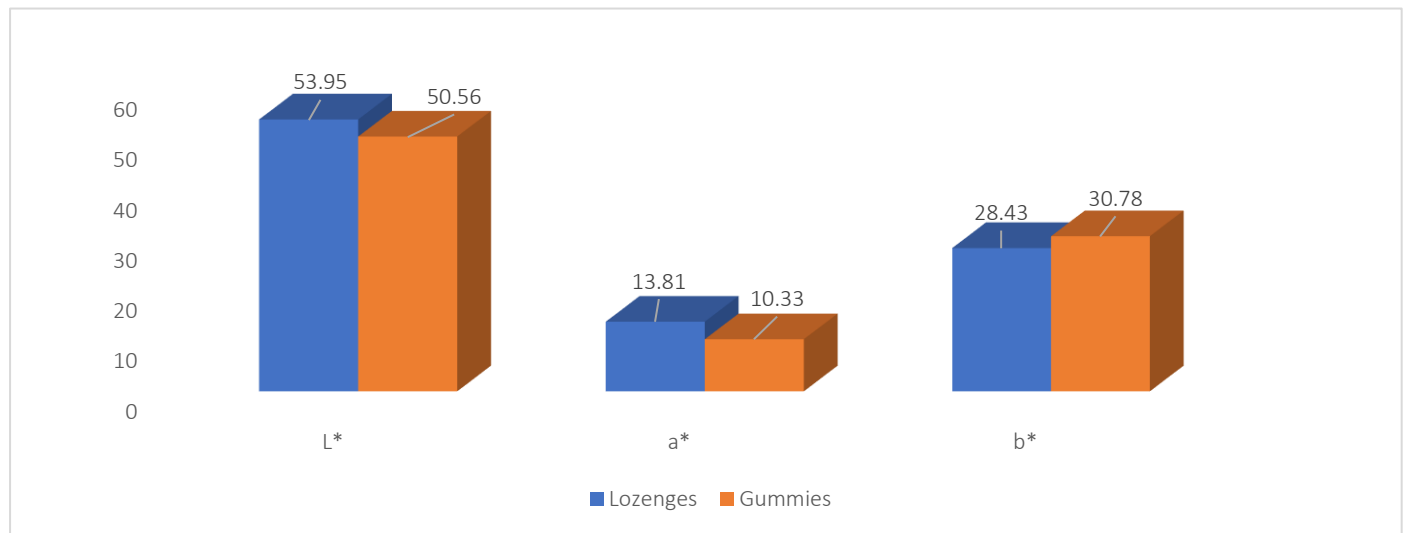


Figure 9. Mean values of color percentage (L^* , a^* , b^* value) of lozenges and gummies.

Note: L^* =lightness. a^* =Red/Green. b^* =Yellow/Blue, Mean \pm SD within the same column followed by different letters is significantly different ($p < 0.05$). SD = Standard deviation of a duplicate sample.

Effect of Phytochemicals Properties on Lozenges and Gummies

Antioxidant activity

Figure 10 indicates the effect of antioxidant activity of lozenges and gummies. The antioxidant property was analyzed by the DPPH (1, 2-Diphenyl-2-picrylhydrazyl) assay method. The analysis of variance of antioxidant activity of lozenges of garlic extract showed the highly significant results. Highest value was observed in T_3 (30.98 ± 0.42) and lowest value were observed in T_0 (0.74 ± 0.01). The value of DPPH in lozenges of T_0 , T_1 , T_2 and T_3 were 0.74 ± 0.01 , 19.62 ± 0.05 , 25.88 ± 0.10 and 30.98 ± 0.42 respectively. The results of this study were in correspondence with Alzahrani *et al.* (2012). Highest value of DPPH of gummies was observed in T_3 treatment (31.81 ± 0.99) and lowest value was observed in T_0 treatment (0.43 ± 0.03). The value of DPPH in gummies of T_0 (0.43 ± 0.03), T_1 (20.47 ± 0.005), T_2 (25.55 ± 0.24) and T_3 (31.81 ± 0.99) as shown in the figure 10. The current study also showed the similar results as demonstrate by Hani *et al.* (2015).

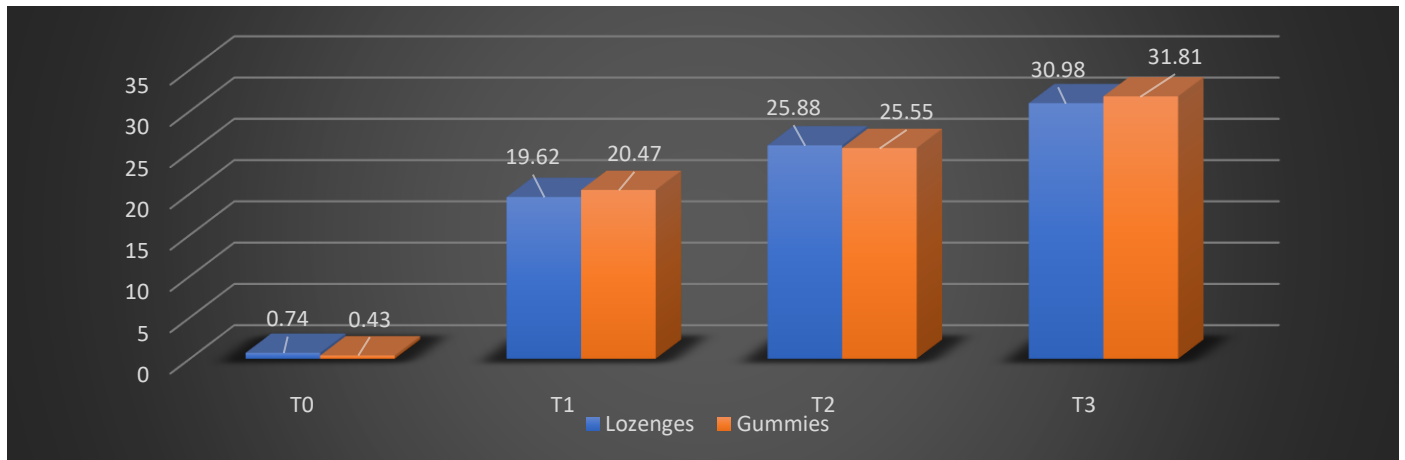


Figure 10. Mean values of antioxidant activity of lozenges and gummies.

Sensory properties of lozenges

Figure 11 shows the mean value of sensory values (texture, color, flavor, appearance, aroma and overall acceptability)

of lozenges. The important framework of quality of any product is color. The results of statistical analysis (ANOVA) revealed that the effect of the treatment on color was noted as highly significant. The sensory ratio for the color value of the lozenge samples varied from 6.9% to 8% with T₃ were least preferred with 6.9±0.99 and T₀ and T₁ as most preferred with 8±1.13 percentage. The findings of this work were comparable to the results of Gopale *et al.* (2022). The results of Lucas *et al.* (2018) were in compliance with current findings. The sensorial ratio for appearance of the lozenge samples ranged from 7.4% to 8% with T₃ are least preferred with 7.4±1.07 and T₀ as most preferred with 8±0.78 percentage, while the mean scores of T₁ and T₂ were 7.7±0.67 and 7.7±0.82. The sensory score for the texture of lozenges samples ranged from 7.2% to 7.5% with T₀ are least preferred with 7.2±1.15 score and T₂ as most preferred with 7.5±0.84 percentage, while the mean scores of T₁ and T₃ were 7.3±0.67 and 7.4±0.84. The sensational percentage for the aroma of lozenges samples ranged from 7.1% to 8% with T₃ are least preferred with 7.1±0.87 score and T₂ as most preferred with 8±0.81 percentage, while the mean scores of T₀ and T₁ were 7.7±0.67 and 7.9±0.73. The sensual ratio for the flavor of the lozenge samples ranged from 7.4% to 7.8% with T₂ are least preferred with 7.4±0.69 score and T₁ as most preferred with 7.8±0.78 percentage, while the mean scores of T₀ and T₃ were 7.7±0.94 and 7.6±1.26. According to the work done by Delgado and Banon, 2015 gives the similar outcomes. And the sensorial rate for the overall acceptability of lozenges products varied from 7.4% to 7.9% with T₁ and T₃ are least preferred with 7.4±0.69 score and T₂ as most preferred with 7.9±0.87 percentage, while the mean score of T₀ was 7.5±0.84. The results are highly significant by using the analysis of variance (ANOVA). Another study done by Lucas *et al.* (2018) has the similar results ranged as 7.7 to 7.8.

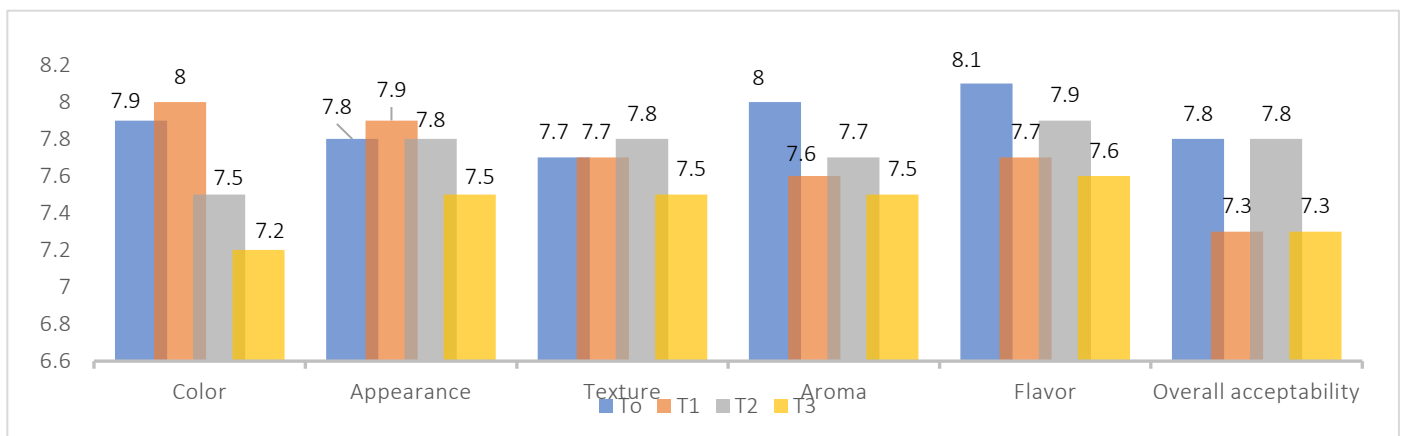


Figure 11. Mean values of sensory values (texture, color, flavor, appearance, aroma and overall acceptability) of lozenges.

Sensory Properties of Gummies

Figure 12 indicates the effect of sensory qualities on sample of the gummies. The mean scores of gummies color for T_0 , T_1 , T_2 , T_3 were recorded as 7.9 ± 0.3 , 8 ± 1.05 , 7.5 ± 0.5 , 7.2 ± 1.13 respectively. The judges gave more score to the gummies made of 10:15 of garlic extract and flavoring agent. The findings of this work were comparable to Gopale *et al.* (2022). The appearance of any product is an important character. The outcomes of statistical study (ANOVA) indicated that the treatments effect on appearance of gummies product was noted as highly significant. The mean scores of gummies appearance for T_0 , T_1 , T_2 , T_3 were recorded as 7.8 ± 0.7 , 7.9 ± 0.8 , 7.8 ± 0.6 , 7.5 ± 1.17 respectively. Judges gave more score to the gummies made of 5% garlic extract and flavoring agent. According to the results, the effects of texture on the treatments indicate the results are highly significant by using the statistical study of (ANOVA). The mean scores of gummies texture for T_0 , T_1 , T_2 , T_3 were recorded as 7.7 ± 0.97 , 7.7 ± 0.8 , 7.8 ± 0.9 , 7.5 ± 0.9 respectively. The gummies product of the treatment T_2 also attain the highest remarks by the judges. The effect of treatments on the aroma of the products gives the non-significant results, according to the statistical study of (ANOVA). The mean scores of gummies texture for T_0 , T_1 , T_2 , T_3 were recorded as 8.0 ± 0.8 , 7.6 ± 0.8 , 7.7 ± 0.9 , 7.5 ± 0.9 respectively. The gummies product of the T_0 treatment of the controlled group obtained the maximum marks. As the results indicate, by using the ANOVA of the statistical study that the overall acceptability showed the highly significant result on the treatments of product gummies. The mean scores of gummies texture for T_0 , T_1 , T_2 , T_3 were recorded as 7.8 ± 0.7 , 7.3 ± 0.8 , 7.8 ± 0.9 , 7.5 ± 1.17 respectively. The other research done by Lucas *et al.* (2018) has the similar results ranged as 7.7 to 7.8.

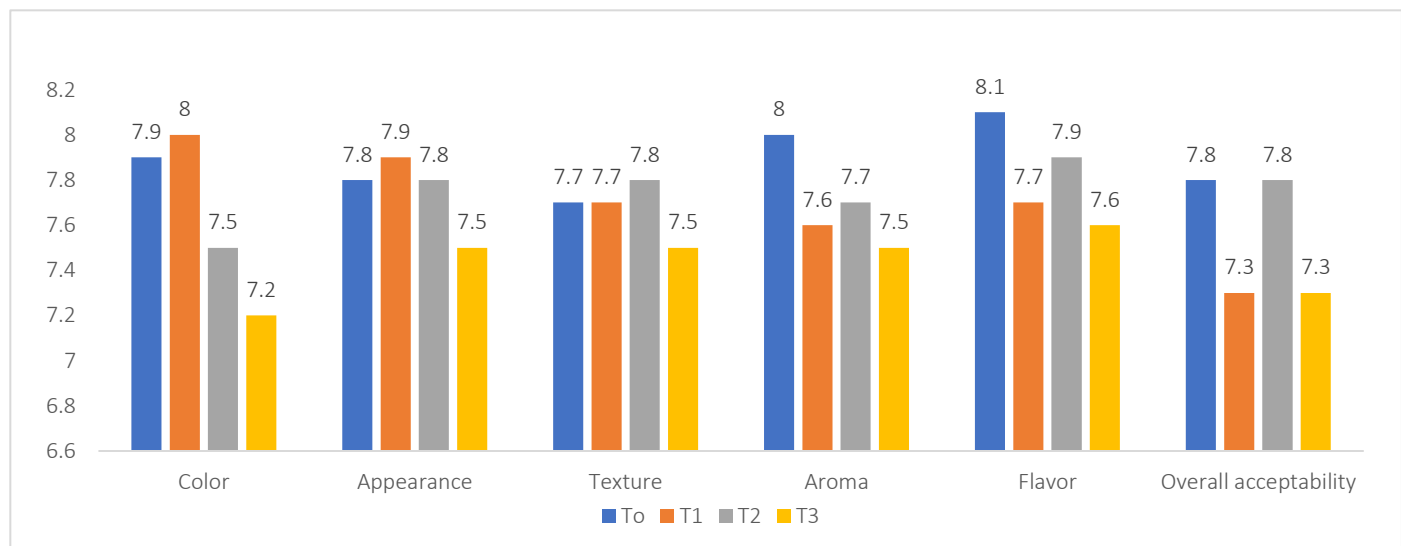


Figure 12. Mean values of the sensory features (texture, appearance, color, texture, flavor, aroma and overall acceptability) of gummies

CONCLUSIONS

This study revealed that the proximate, minerals, and antioxidant activity of the lozenges and gummies prepared from garlic are nutritionally enriched and superior than the commercialized lozenges sample (the control group). Antioxidant activity (DPPH assay) of the treatment 3 was greater than the control group. The lozenges consisting 75% sugar, 15% flavoring agent and 10% garlic extract have overall best sensory evaluation. The gummies consisting 65% sugar, 15% flavoring agent, 20% gelatin and 10% garlic extract have overall best sensory evaluation.

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AUTHOR CONTRIBUTIONS

Not applicable.

COMPETING OF INTEREST

No conflicts of interest have been disclosed by the authors.

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