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RESEARCH ARTICLE
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"EXPLORING THE THERAPEUTIC POTENTIAL OF GARLIC THROUGH THE FORMATION OF FUNCTIONAL SPREAD"

Maimoona Waheed[1*], Mian Kamran Sharif[2*], Madiha Ghazanfar[3*], Haseeb Ahmed[4], Amna Hameed[5], Nabila Nudrat[6], Fatima Amjad[7] Madiha Iftikhar[8], Ammar Ahmed[9], Iram Saba[10], Amanullah Sabir[11], Muhammad Zain Abdullah[12]

[1*,3*,4,5,7,8,9]Department of Diet and Nutrition Sciences, Ibadat International University, Islamabad. haseeb.ahmed@ddns.iiui.edu.pk,. Amna.hameed@dnsc.uol.edu.pk, fatima.amjad@ddns.iiui.edu.pk, madiha.iftikhar@ddns.iiui.edu.pk, ammar.ahmed@mlt.iiui.edu.pk
[2*]National Institute of Food Science and Technology, University of Agriculture, Faisalabad.
[6]Allama Iqbal open university Islamabad. nabilakhattak55@gmail.com
[10]Department of Chemistry, Faculty of Natural Sciences, GC Women University Sialkot, Pakistan iramsaba602@yahoo.com
[11]Department of Food Science, Government College University Faisalabad, 38000 Pakistan. amaanullahsabir@gmail.com
[12]Department of Biotechnology, Faculty of Science and Technology, Virtual University of Pakistan - Faisalabad Campus, Pakistan mr.zanu786@gmail.com

***Corresponding Author:** Maimoona Waheed, Mian Kamran Sharif, Madiha Ghazanfar
*email: maimoona.waheed@ddns.iiui.edu.pk, mks@uaf.edu.pk, madiha.ghazanfar@dnsc.uol.edu.pk

ABSTRACT

Advancement in lifestyle and abject eating habits paved a path towards the compromised nutritional status. Increased consumption of fast food and instant meals demand to be nutritionally adequate in order to lower the increased burden of NCD's. Among the instant food, bread spread is third most commonly used product by consumers. It is consumed throughout the day during a meal and snacking. However, such type of products are not widely available in markets especially in Pakistan and mostly imported from United States. In this, various spread like garlic enriched spread can promise various functional and therapeutic benefits. Garlic (*Allium sativum*) is an aromatic herbaceous plant that is consumed worldwide as food and traditional remedy for various diseases, having several biological properties including anticarcinogenic, antioxidant, antidiabetic, renoprotective, anti-atherosclerotic, antibacterial, antifungal, and antihypertensive activities. The present project was designed to prepare indigenous garlic enriched functional spread. For this purpose garlic was converted into paste in different combinations T_1 (2% garlic), T_2 (3% garlic) and T_3 (4% garlic). Garlic spread was prepared and evaluated for phytochemical *i.e.* total phenolic content (4.56 to 4.70), total flavonoid content (1.27 to 1.94), and antioxidant potential (0.76 to 0.97). All formulations was converted into functional spread followed by their assessment for color, and texture. Sensory acceptability of the product was judged for different attributes like color, taste, aroma, texture, mouthfeel and overall acceptability. The data obtained from different tests was analyzed statistically.

Key words: *Allium sativum*, Garlic, Garlic spread, phytochemical analysis

INTRODUCTION

The main protective food in our everyday life is vegetables, which not only benefit us with essential nutrients but also with the plenty of bioactive compounds. The generic name *Allium* originated from Celtic word "all" which means pungent. Garlic (*Allium sativum*) is among the most important vegetable grown in Central Asia. The bulb of garlic serves as house of odorless, colorless and water soluble compound known as allicin. Garlic is used as a condiment in Asia. It contain vitamin B complex, flavonoids, certain minerals and enzymes. It is marked as a good source of antioxidants. It is the central ingredient in the Mediterranean diet and traditionally used in Asian, European and African dishes. Garlic is most widely cultivated and used allium specie after onion. It has been utilized all over the world from many past decades as an important spice, and a well-known antidote for various physiological disorders and ailments.

Garlic cloves stores about 6mg/g of allicin which cohere to 1.7 % of the dry weight. They also have 2.8% of alliinase protein on the basis of dry weight. Allicin also showed antibacterial properties against animal bites and other damage (Singh *et al*., 2019). Intake of garlic has not been standardized yet. German Commission E monograph proposed that daily intake of 1-2 garlic cloves or 4g raw intact garlic may possess health enhancing properties (Verma *et al*., 2020). Garlic is a natural health promoter and a wonder drug available naturally. It has antiinflammatory properties, as well as antiviral, against gram-positive and gram-negative bacteria accompanying anti parasitic activity against several human intestinal protozoans. Garlic extract has shown positive results when used as a natural blood thinner and potential to lower cholesterol level. Consequently, used as a conventional medicine for the treatment and prevention of cardiovascular diseases. As long as garlic plant use allicin as its most efficacious defender against microbial and fungal attacks, or from antioxidant and anticancer properties.

Studies has proved that garlic is effective in the treatment of the cardiovascular diseases and have cholesterol lowing effects (Kleijnen *et al*., 2019). Mankind is believed to be the only soul that eats garlic. Garlic has a strong flavor and pungent taste, therefore eating it results in halitosis (bad breath). Therefore, food scientists and researchers have used various methods such as blanching, marination and fermentation to reduce these discomforts. Marinated garlic has no strong odor and can be consumed like a fruit (Tahir *et al*., 2022).

Advancement in lifestyle and abject eating habits paved a path towards the compromised nutritional status. Increased consumption of fast foods and instant meals demand to be nutritionally adequate in order to lower the increased burden of NCD's. Because Asia is home to half of the world's population, cardiovascular disease (CVD) prevention is an essential concern for global health. The modern man's busy and sedentary lifestyle may be to blame for the rising occurrence of cardiovascular disorders. In this era the choice of healthy food item can have a preventive role towards rising curve of non-communicable diseases.

Recently it has been recognized that there exist a strong relationship between the food we consume and the health status of a person. With the increased in modernization, the idea for increased consumption of instant and ready-to-eat food is in the limelight. Mostly snacks which are consumed in this industrialized era are high in energy density instead of nutrient dense. Among the instant food, bread spread is third most commonly used product by consumers. These are consumed throughout the day during a meal and snacking. Bread spread is an instant meal item that fits people's busy lifestyle and is a modest way to provide nutrition. It is considered as the food which is spreadable on some other food and often compliment snacks. However, such type of products are not widely available in markets especially in Pakistan and mostly imported from United States.

In this, various spread like garlic supplemented spread can promise various functional and therapeutic benefits. A number of spreads has been made from different vegetables and fruits. Despite the fact that garlic has many promising health-protecting and promoting properties, such as anticarcinogenic, antioxidant, antidiabetic, reno-protective, antiatherosclerotic, antibacterial, antifungal, and

antihypertensive properties, its use in everyday life has been discouraged due to its pungent taste and bad smelling mouth. Garlic can be used in a variety of ways in everyday life. It has been added to our meals while cooking to add flavor and nutrition. Garlic spread formulated with blends of garlic paste has not been documented yet. Garlic has less calories, sugar, fat and sodium. Despite all used in lesser quantities. Therefore, it does not contribute to overall nutritional intake. Garlic supplemented spread can be a cost effective and health protective instant food snack for most of the population. The development of spread from garlic, egg and extra virgin olive oil blends will improve the garlic consumption as well as provide the functional food for the health conscious consumers.

MATERIALS AND METHODS

Procurement of Raw Material

The fresh garlic was procured from Imtiaz Mega Islamabad. Other ingredients like extra virgin olive oil, eggs, sugar, and salt required to prepare spread were purchased from the same supermarket.

Preparation of Garlic Paste

Garlic was first peeled and the garlic cloves were washed with water to get rid of any dust or unwanted/harmful particles. The garlic cloves were chopped into fine paste with the help of electric chopper. When the fine paste was formed then it was placed in airtight glass jar at room temperature for further use in the different treatments (samples).

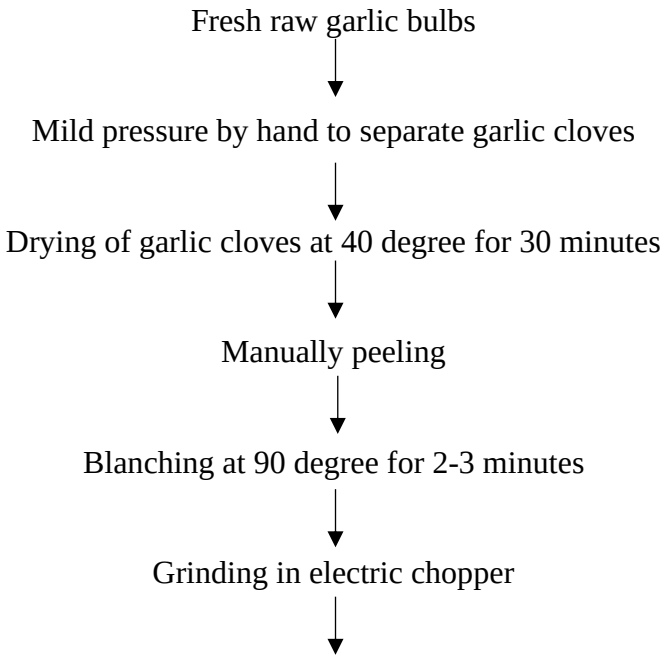

Fig. 1. Preparation of garlic paste

Characterization of Garlic Paste

The prepared garlic paste was analyzed to determine its nutritional characteristics including chemical composition, proximate, mineral and phytochemical analysis.

Phytochemical Analysis

Sample Preparation for Antioxidant Capacity

Five grams of fresh garlic was chopped and homogenized in a small blender (Rocket blender; Bella Cucina, Atlanta, GA, USA) with 50 ml solvent twice for 1 min. Five grams of garlic paste was homogenized and 1 g each dry garlic was ground using a mortar and pestle and also homogenized in a small blender (Rocket blender, Bella Cucina) with 50 ml water twice for 1 min. The samples were sonicated for 20 min. After centrifugation at 2,400 × *g* for 10 min, an aliquot of 1 ml was further diluted with sodium/potassium buffer (Na/K) buffer (75 mmol/l, pH 7.0) depending on the antioxidant

activity of the garlic. To optimize the extraction, the first batch of garlic was extracted with both solvents (100% water and 50% methanol: 50% water). Since there was no significant difference in antioxidant capacity between the two extracts in batch 1, so continued using only water extraction for batches 2 and 3.

Total Phenolic Content Analysis

The total phenolic content was determined according to the Folin–Ciocalteau method. Then 0.5–1.0 g garlic paste was homogenized in a small blender with 50 ml of 80% methanol–20% H_2O twice for 1 min. The mixture was sonicated for 20 min, and centrifuged (18,000 × g) for 10 min. The supernatant was diluted 1:100 as appropriate with methanol–water (1:1) and 200 µl sample was incubated with 3 ml methanol–water (1:1) and 200 µl Folin–Ciocalteau reagent for 10 min at 25°C. Then 600 µl of 20% Na_2CO_3 solution was added to each tube and mixed well. Tubes were further incubated for 20 min at 40°C. After incubation, samples were immediately cooled in an ice bath to room temperature. Samples and standards (gallic acid) were processed identically. The absorbance was determined at 755 nm (VersaMax microplate reader; Molecular Devices) and the final results calculated from the standard curve.

Development of Functional Spread

Initially, a spread was prepared using egg whites (2 medium sizes), extra virgin olive oil (250ml), salt and sugar (as per taste). All these products was finely chopped in the electric blender for the time of 5 minutes. Then the spread was supplemented with different proportions of garlic paste considering their therapeutic potential. The therapeutic spread was prepared by gradually replacing spread and garlic paste as described in the Table 3.1. The shelf life of garlic supplemented spread was found to be 4-5 days at room temperature (25°C) with no preservatives added. Garlic supplemented spread was prepared by using the modified method of Olaleye *et al*. (2021).

Table 1. The treatment plan used for garlic supplemented spread

Treatments	Garlic (%)
T_1	2
T_2	3
T_3	4

T_1 = Spread supplemented with 2% garlic, T_2 = Spread supplemented with 3% garlic, T_3 = Spread supplemented with 4% garlic

T_1 T_2 T_3

Fig. 2. Formation of different treatments of functional spre

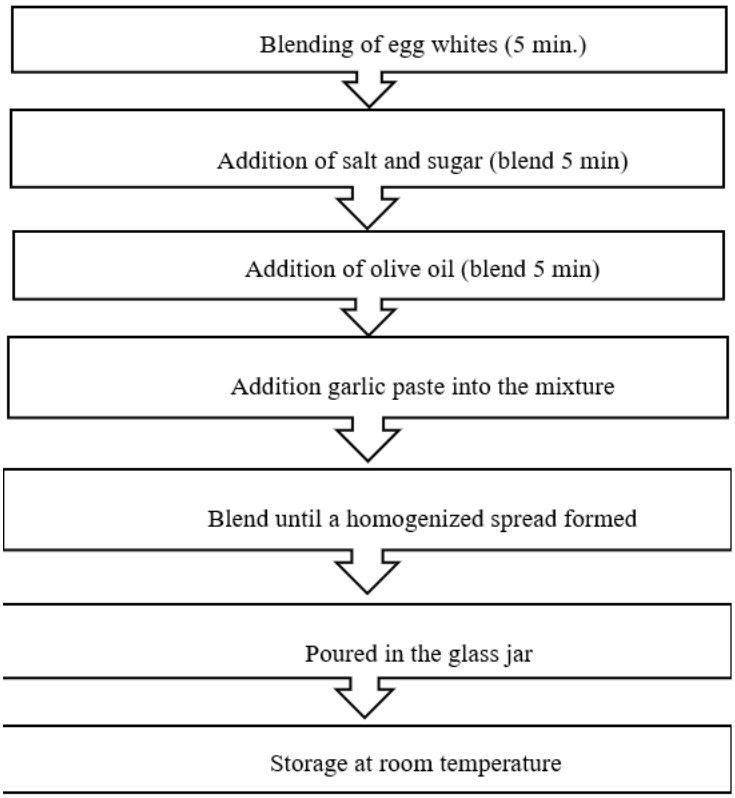

Fig. 3. Preparation of therapeutic functional spread

Fig. 4. Garlic supplemented functional spread

Analysis of Therapeutic Functional Spread

Phytochemical Analysis

The developed product was analyzed for TPC, TFC and antioxidant capacity (Abubakar *et al*., 2022).

Color Analysis

A colorimeter was used to evaluate the color of functional spread (Baycar *et al*., 2021). The color sample cell was used for observing L*, a* and b* value for color measurement of the sample.

Texture Analysis

The product was analyzed for texture analysis by following the respective method of (Lis *et al*., 2021). For this purpose TA-TXT plus texture analyzer (Stable Microsystem, Godalming, U.K.). The analyzer was connected with computer. Three measurements was repeated for each sample in-order to calculate the mean value. Based on the respected curves, various attributes (firmness, spreadibility, and stickiness) was evaluated.

Sensory Evaluation

The therapeutic spread was given to a group of qualified judges with proficiency in sensory evaluation from the NIFSAT to evaluate its acceptability and quality. The sensory evaluation was conducted on a 9-point hedonic scale for color, taste, aroma, firmness, spreadibility, stickiness and overall acceptability.

Statistical Analysis

The results obtained from the characterization and preparation of functional spread was analyzed statistically under the completely randomized design (CRD) and ANOVA in-order to highlight the significance level (Montgomery, 2017).

RESULTS AND DISCUSSION

The current study was conducted in Food and Nutrition Lab, National Institute of Food Science and Technology, University of Agriculture, Faisalabad. Garlic was the main research ingredient used in this study. Firstly, garlic was converted into fine paste. Then, garlic paste was analyzed for proximate analysis before supplementing into the spread. It was also analyzed for the selected minerals, total phenolic content (TPC), total flavonoid content (TFC) and antioxidant potential. Afterwards, functional garlic spread was prepared using different percentage of garlic and the blends of egg, oil and supporting ingredients. Functional spread was then subjected to proximate analysis, mineral analysis, phytochemical analysis, color, and texture. Furthermore, sensory evaluation was carried out by color, taste, aroma, texture, mouth feel, and overall acceptability. Based on chemical composition and better sensory attributes, the best composition *i.e*. T_2 (functional spread supplemented with 3% garlic paste) was selected. The results on various aspects of the study are discussed as follows:

Analysis of Raw Material

Phytochemical Analysis

Total phenolic content (TPC)

Means of total phenolic content of garlic has been shown in the Table 4.3. Polyphenolic compounds are plant-based secondary metabolites and they possess antioxidant properties which makes them important compounds from the nutritional point of view. Their presence in any food material makes the food healthy and good for consumption. Fruits and vegetables are high in polyphenols and are used to prevent a variety of disorders. The higher the polyphenol concentration, the slower the oxidative breakdown of lipids, which is of importance to the food industry and thereby, improves food quality and nutritional value (El-Sayed and Youssef, 2019). The results of current study clearly illustrated that the mean values of total phenolic content in garlic was 1026.20±71.83mg GAE/g of garlic (Wijewardhana *et al*., 2019).

The results are supported by the finding of Selen. (2019) The major group which contribute towards the antioxidant activity of vegetables are mainly phenolic compounds. Similar results were also determined by Bystricka *et al*. (2018) who reported the value of TPC 1051mg GAE/kg. Tahir *et al*. (2022) studied the TPC of fermented and raw garlic. They found that fermented garlic have the highest TPC 1086.73mg GAE/kg compared with raw garlic 1421.27mg GAE/kg. Their results highlighted that many phytochemicals exist in garlic both in raw and fermented form. They also highlighted that the specific smell, color and flavor of the garlic is attributed to these phenolic compounds.

Table 2. Phytochemical composition of garlic

Parameters	Garlic
Total phenolic content (TPC) (mg GAE/100g)	1026.20±71.83
Total flavonoid content (TFC) (mg RE/100g)	29.95±2.09
Antioxidant potential (DPPH) (mg TEAA/100g)	2.45±0.17

Total flavonoid content (TFC)

Table 4.3. depicted the means of total flavonoid content and DPPH of garlic. It shows that garlic contained 29.95±2.05 RE/100g of total flavonoids and 2.45±0.17 TEAA/100g of DPPH. The results are in agreement with Akbarpour *et al*. (2021). Flavonoids are the most abundant naturally occurring phenolic compounds found in various plant sections, both free and as glycosides. Total flavonoid contents are the key quality parameter concerned with antioxidant potential of vegetables. They are secondary metabolites of plants which are mainly known as vitamin P like agents. Antioxidant capacity of garlic is mostly due to its saponins, flavonoids, organosulfur compounds, phenolic components and DPPH. This potential is larger in water-soluble organosulfur compounds with antioxidant ability (e.g., SAC and SAMC) in aqueous extracts (e.g., AGE) than in raw garlic or other preparations.

Analysis of Garlic Supplemented Functional Spread

Phytochemical Analysis

Total phenolic content (TPC)

The mean squares (Table 4.8.) for the TPC of various treatments reveals that supplementation significantly affected spread formulations. The mean results of the study (Table 4.9.) demonstrated that different treatments affect the total phenolic content in the spread. TPC have ranged from 1026.20 to 1039.28mg GAE/100g of dry matter. The highest range of phenolic was found in T_3 (32.90) which is 4% supplemented spread. The minimum content of phenolic was present in T_1 (31.92). The phenolic content in other treatment also differ significantly. The (Table 4.9.) shows upturn trend in the phenolic content of the functional spread from T_1 to T_3. The phenolic content increased in the order T_1 (31.92), T_2 (32.27), and T_3 (32.90). It has been observed the phenolic content is directly related to the content of garlic. Garlic is one of the most abundant sources of phenolic compounds in the human diet. In epidemiological research, there was a negative connection between the presence of polyphenols in the body after consumption and death from heart disease and stroke (Oszmianski *et al*., 2013). Variation in the level of phenol in the treatments is due to difference in the amount of garlic.

These results are in line with the findings of Bystricka *et al*. (2018) compared TPC value of garlic. They found that garlic had the highest score for total phenol compounds (TPC). Their primary role is to influence sensory characteristics. These substances contribute to the production of turbidity and sediment in the food products. It is important to note that conditions of cultivation, and methodology have significant influence on the contents of phenolic (Martins *et al*., 2016). The difference in results may be due to many factors such as the sensitivity of phenolic compounds to oxidation by air and temperature.

Table 3. Means for total phenolic content, total flavonoid content, antioxidant potential of functional spread

Treatment	TPC (mg GAE/g)	TFC (mg RE/g)	DPPH (%)
T_1	31.92 ± 2.0^{c}	8.89 ± 0.6^{a}	0.76 ± 0.05^{a}
T_2	32.27 ± 2.2^{b}	12.61 ± 0.8^{b}	0.80 ± 0.04^{b}
T_3	32.90 ± 2.3^{a}	13.58 ± 0.9^{c}	0.97 ± 0.06^{c}

T_1 = Spread supplemented with 2% garlic paste

T_2 = Spread supplemented with 3% garlic paste

T_3 = Spread supplemented with 4% garlic paste

Total flavonoid content (TFC)

The mean squares (Table 4.8.) for the TFC of various treatments reveals that supplementation significantly affected the total flavonoid content. It is clear from the (Table 4.9.) that means of TFC have ranged from 8.89 to 13.58mg RE/g of dry matter. The maximum range has been observed in 4% supplemented spread (13.58). The minimum range is present in the T_1 (8.89) with 2% garlic based spread. The phenolic content in other treatments also differ significantly. The content of phenols in different treatments increases in order T_1 (8.89), T_2 (12.61), T_3 (13.56). The results are in line with supporting study of Ceryova *et al*. (2021). Binding of phenols has been observed to be greatly influenced by the heating. These differences in total phenolic content in garlic may vary due to genetic as well as environmental conditions. Heat processing techniques also affect the flavonoid content.

Antioxidant Assay

The mean squares (Table 4.8.) for the DPPH of various treatments. Antioxidant potential of garlic supplemented functional spread was reveals that supplementation has significant effect on DPPH value. Antioxidant assay analyzed by DPPH method. Antioxidant potential means the prevention or limitation of oxidation of cellular structures and other molecules present in living cells. Antioxidant activity exhibiting compounds directly or indirectly scavenge the free radicals and protect the cell structures from any kind of deformity or abnormality. It is clear from the (Table 4.9.) that means of DPPH have ranged from 0.76% to 0.97%. The highest potential (0.97) has been observed in spread supplemented with 4% garlic. The minimum potential was present in the T_1 (0.76) with 2% garlic. The antioxidant potential increases from T_1 to T_3 by the addition of garlic in the functional spread. The antioxidant potential increased in order T_1 (0.76), $<T_2$ (0.80), $<T_3$ (0.97). The variation in the antioxidant potential might be the consequences of differences in the added concentrations of garlic. Antioxidant activity increased with the increase in garlic level. An increase in the total phenolic content from level 31.92 to 32.90 was detected in the sample of garlic spread in the present study. Scavenging Activity of Diphenyl-2-picrylhdrazyl (DPPH) DPPH is a stable free radical that is used to assess antioxidant activity. It is being utilized to identify the scavenging activities as well as it can check the suppression of oxidation or reactions endorsed by oxygen (O_2), peroxides (H_2O_2), and harmful impacts of free radicals. Scavenging Activity of Diphenyl-2-picrylhdrazyl (DPPH) was observed of the functional spread. Dewi *et al*. (2018) studied the antioxidative stability of garlic and how it improves the functional properties of food products. Polyphenols and antioxidant of dip showed greater correlation with each other (Li *et al*., 2016). Ginger garlic dip indicated an antioxidant potential of (11.8uM/ml.) which was greater than the plain dip (7.6µM/mL). Through post hoc analysis, it was observed that significantly higher antioxidant potential was seen in the ginger, garlic dip *i.e*. (22.6µM/mL). This showed that both ginger as well as garlic act as products to increase the potential of antioxidants (Jung *et al*., 2021). Garlic has advantage for its bulkiness and reducing the carbohydrate in the dip while increasing levels of antioxidant. Longevity of the product is one important factor. In the study, it was concluded that shelf life can be improved by the addition of ginger and garlic because of the effects of their enhanced antioxidants and phytochemical levels. Spread type had significant effect on the antioxidant capacity. The difference in the results was due to processing conditions that effect the antioxidant properties of phytochemicals.

Color Analysis

Table 4.10. Indicated the mean squares for the L*, a* and b* value of functional spread. The color scale factors (L*, a*, b*) were assessed of functional spread using illuminant. The lightness (L* value) ranges from 0 (black) to 100 (white). The a* and b* values have no numerical limits. a* value means redness (+red to -green) and the b* value implies yellowness (+yellow to -blue). For each spread treatment, values were taken at three different locations. Means for the L*, a* and b* value of functional spread were given in the Table 4.11. For each treatment values are taken at three different locations. According to the evidence of the mean squares, all treatments have a significant effect on

the L* value of garlic supplemented functional spread. With the addition of garlic, a decrease in L* value increase in a* value and b* value was observed.

The results in line with Kim *et al*. (2022) who described the addition of ginger extract causes an increase in yellowness (b* value) and redness (a* value) and loss of lightness (L* value). Likewise (Putra, 2019) witnessed the addition of garlic polyphenols directed to rise in a* and b* values. With increasing storage period increase is seen in both a* and b*, but the difference was significant only for a* value of spread with 2% garlic added and for the b* value at a ginger extract concentration of 1g/kg of spread. Many factors influenced the color of traditional spicy sauce cubes, including the browning reaction of spicy sauce paste during cooking, the natural colors presented by fresh foods and the Maillard reaction occurs in several cyclic drying processes temperature. The color of onion in the research methods and garlic, which may have contributed to the brownish color because of the addition of water during paste preparation.

During storage, spread goes through a chain of chemical and biochemical changes that might make color alterations. It has been described that the existence of high levels of phenolic compounds in garlic spread is cause for enzyme-catalyzed discoloration. The modification of color by adding garlic paste may have an impression on consumer acceptability.

Table 4. Mean table for color analysis of garlic supplemented functional spread

Treatment	L* value	a* value	b* value
T_1	85.32 ± 0.02^a	-4.12 ± 0.02^c	27.85 ± 0.02^c
T_2	82.71 ± 0.03^b	-3.87 ± 0.01^b	28.14 ± 0.01^a
T_3	78.24 ± 0.03^c	-3.71 ± 0.02^c	28.47 ± 0.03^b

T_1 = Spread supplemented with 2% garlic paste; T_2 = Spread supplemented with 3% garlic paste; T_3 = Spread supplemented with 4% garlic paste

Texture Analysis

The mean squares (Table 4.12.) for the texture analysis of various treatments reveals the hardness, springiness, and gumminess of functional spread. According to the evidence from the mean squares all treatments having a significant effect on the hardness of garlic spread. Table 4.12. indicated the statistical analysis for the 3 treatments having a significant effect on the springiness of garlic ranginess of garlic supplemented functional spread. According to the evidence from the mean squares there was a significant effect on the gumminess of garlic supplemented spread. Table 4.13. shows the mean values for texture properties in garlic supplemented spread. It can be evidenced that the highest value for hardness (4.82N), springiness (0.68mm), and gumminess (1.37N/m) were found in garlic supplemented functional spread. On the other hand, the lowest value of hardness (0.67N), springiness (0.41mm), and gumminess (0.43N) were found in garlic supplemented spread treatments *i.e.* T_1, T_2 and T_3 respectively. The results of current study are line with Guemouni *et al*. (2023) developed many sauce recipes utilizing varying quantities of garlic powder. They reported that the addition of garlic to sauce had no detrimental effect on the overall texture of the food product, but the sauce was supplemented with health-promoting nutrients that contribute to the consumer's overall good health.

As compared to plain spread the hardness, springiness and gumminess were higher in garlic supplemented functional spread. Moisture contents in the garlic supplemented spread caused higher hardness as compared to sample having low amount of garlic. DeMenezes *et al*. (2022) stated with the decrease in moisture contents the level of hardness significantly increases. The texture profile of samples these also demonstrates that in the garlic supplemented spread springiness is low. In the flavored spreads, a high-fat ratio and acidity might be the causes of low springiness. Lower gumminess values of garlic spread could be correlated to a higher protein ratio compared to plain these without garlic essential oil (Rakic *et al*., 2022).

Table 5. Means for texture analysis of functional spread

Treatment	Hardness	Springiness	Gumminess
T_1	0.67 ± 0.02^c	0.68 ± 0.09^a	0.43 ± 0.01^c
T_2	3.14 ± 0.45^b	0.41 ± 0.11^c	1.29 ± 0.04^a
T_3	4.82 ± 0.67^a	0.53 ± 0.01^b	1.37 ± 0.01^b

T_1 = Spread supplemented with 2% garlic paste
T_2 = Spread supplemented with 3% garlic paste
T_3 = Spread supplemented with 4% garlic paste

Sensory Analysis

Results obtained from organoleptic characteristics which includes color, taste, aroma, texture, mouth feel, and overall acceptance were evaluated by sensory panel using 9-point hedonic scale. Sensory analysis was conducted to know about the consumer behavior regarding product acceptance or rejection. The results pertaining to all sensory parameters of spread are discussed in detail below:

Color

Means square (Table 4.14.) for sensory evaluation of spread shows that addition of garlic had significant effect on color. Results of mean values (Table 4.14.) of color ranged from 6.26 to 7.01. T_2 (7.40) was liked by the judges in terms of color and T_1 (6.26) was not liked in terms of color. The color of food product is as central as taste for quality guarantee of the food. According to marketers, color is one of the major factors that affect the buying behavior of customers and consumers. Mostly consumers decide the flavor of food product based on its color.

Taste

Mean square of score given to taste of spread prepared from different formulations of garlic are shown in Table 4.14. The results (Table 4.15.) depicted that there appeared a significant variation in score of spread among different treatments. Results describe mean value for taste of treatments T_1, T_2 and T_3 were 8.01, 7.39, and 7.34 respectively. T_2 got the score 7.34. Judges did not like the taste for T_3 as it has slight high garlic flavor and give it the lowest score among all (7.34). This shows that increase in the percentage of garlic in functional spread alters the taste in unacceptable manner. The results are supported by the Mahmood *et al*. (2019) who reported a decrease in taste score of sauce as the percentage of garlic increases. The taste score decreases from 8.01 to 7.34

Aroma

Table 4.14. exhibits the mean square of the scores given to the texture of the product made from different composition of garlic. Results (Table 4.15.) describe mean value for taste of treatments T_1, T_2 and T_3 are 7.01, 7.29, and 6.04 respectively. T_2 got the score 7.29. Judges did not like the aroma for T_3 as it has slight high garlic flavor and give it the lowest score among all (6.04). This shows that increase in the percentage of garlic in functional spread alters the aroma in unacceptable manner. The results are supported by the Mahmood *et al*. (2019) who reported a decrease in aroma score of sauce as the percentage of garlic increases. The aroma score decreases from 7.29 to 6.04.

Table 6. Means for the sensory evaluation of functional spread

Treatment	Color	Taste	Aroma	Texture	Mouth feel	Overall acceptability
T_1	6.26 ± 0.23^{a}	7.10 ± 0.13^{b}	7.09 ± 0.09^{c}	7.07 ± 0.06^{a}	7.10 ± 0.20^{a}	6.40 ± 0.13^{b}
T_2	7.40 ± 0.12^{b}	7.28 ± 0.42^{a}	7.85 ± 0.54^{a}	7.28 ± 0.41^{ab}	7.57 ± 0.70^{c}	7.12 ± 0.41^{c}
T_3	7.01 ± 0.02^{c}	6.87 ± 0.30^{c}	7.20 ± 0.72^{b}	6.81 ± 0.11^{a}	6.74 ± 0.34^{b}	6.07 ± 0.23^{b}

T_1 = Spread supplemented with 2% garlic paste
T_2 = Spread supplemented with 3% garlic paste
T_3 = Spread supplemented with 4% garlic paste

Texture

Mean square (Table 4.14.) showed that texture of spread affected by addition of garlic paste. Results (Table 4.15.) describe mean value for texture of treatments T_1, T_2 and T_3 are 7.07, 7.28, and 6.81 respectively. Highest value of texture was observed in T_2 and lowest was seen in T_3. Similar results were supported by Mahmood *et al*. (2019). Texture is important in determining the eating quality of foods and can have a strong influence on food intake and nutrition. Texture score of current study ranges from 7.07 to 6.81.

Mouth feel

Table 4.14. exhibits the mean square of the scores given to the mouth feel of the product made from different composition of garlic. Results (Table 4.15.) describe mean value for mouth feel of treatments T_1, T_2 and T_3 are 7.10, 7.57, and 6.74 respectively. T_2 got the score 7.57. This shows that increase in the percentage of garlic in functional spread alters the mouth feel in unacceptable manner. The results are supported by the Mehmood *et al*. (2019) who reported a decrease in mouth feel score of sauce as the percentage of garlic increases. For the quality assurance of food products, mouth feel is considered as the important sensory attribute. It is defined as physical sensation in mouth due to some food or drink.

Overall acceptability

Acceptance is evaluated through hedonic scale tests to assess the overall liking and degree of liking for individual sensory attributes. Mean value and standard deviation for overall acceptability of different types of treatments were measured and represented in table 4.15. There was a no significant difference among all the treatments. All the treatments had shown the result that there was no such impact on the overall acceptability of the product. The slight differences were found but this change was not significant in accordance with these treatments. These findings are correlated with the findings of Flamminii *et al*. (2020) who measured the organoleptic characteristics of mayonnaise fortified with olive phenolic extracts supplemented with garlic. They reported that the sensory evaluation of supplemented mayonnaise had lowest total acceptance score. Also, the fortified mayonnaise showed a lower spreadibility and greater bitter and salty taste, which lead to the decrease in overall acceptance of product. In addition, DeSouza *et al*. (2020) prepared mayonnaise as a model food for improving the bio accessibility of fruits and reported the product developed had high acceptance in all measured sensory characteristics.

Conclusion

Currently, the food industry is focused on producing food items with good sensory attributes and high nutraceutical properties. Flavor loss in spread is a common problem under storage conditions. Therefore, the current research trial was conducted to evaluate the impact of garlic spread. Different parameters regarding physicochemical attributes, antimicrobial, and antioxidant activity were observed. Results exhibited that garlic have a significant impact on physicochemical attributes. The higher total phenolic contents (32.90mg GAE/g) were observed under 4% garlic application. Similar results were observed regarding sensory attributes where the application of garlic improved the hardness, springiness, and gumminess of spread. However, color, taste, aroma, and overall acceptability were significantly enhanced under 3% garlic.

The reported results have suggested that these effects could be due to the presence of volatile compounds present in the extract and essential oil of garlic. The findings of the present study could be helpful to offer a wide range of flavored spread varieties with multifunctional health benefits desirable for consumers. The physical properties of garlic flavored spread reveal that it has more taste and flavor without compromising appearance compared to simple spread. Spread should be preferred in diet due to nutritional content so that it can be used as substitute of nutrient deficient products.

Declaration of Competing Interest:

The authors declare that they have no conflict of interests.

Data Availability Statement: The authors confirm that the data generated or analyzed supporting the findings of this study are available within the article, and any further supporting material will be provided upon request from the corresponding author.

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