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Comparative Phytochemical, Physicochemical and Proximate Analysis of Oils from Garlic (*Allium sativum*) and Black Cumin (*Nigella sativa*)

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Abstract
Garlic (Allium sativum) and Black Cumin (Nigella sativa) oils have been used for centuries in traditional medicine and as food ingredients, due to their numerous health benefits and nutritional worth. This study aimed to carry out a comparative analysis of the phytochemical, physicochemical, and proximate composition of garlic and black cumin oils. Soxhlet extraction method using hexane was used for extracting the oil. Phytochemical screening was conducted using standard methods. Physicochemical, antinutritional and proximate analysis were done by standard methods. The qualitative phytochemical analysis revealed the presence of flavonoids, terpenoids, phenols, saponins, steroids and glycosides. Proximate analysis, revealed the nutrients as: moisture (6.57-7.12%), crude ash (1.33.-7.39%), crude protein (7.87-20.3%), crude fat (0.52.-31.4%), crude fibre (0.73-2.03%) and carbohydrate (18.06-19.7%). Antinutritional factors were recorded with values: oxalate (3.4-5.5%), alkaloids (5.4-6.3%) and phytic acid (6.7- 8.3%). Physicochemical analysis showed these values: free fatty acid (2.10-7.34%), acid value (4.18-12.93 mg/g), saponification value (192-190.35 mgKOH), pH value (6.64-6.03), iodine value (12.69-120.65mg/g) and colour (whitish to blackish). Phytochemicals in the oils may be responsible for its use in treatment of diseases. The study highlights the potential health benefits of Garlic and Black Cumin oils, particularly in the prevention and treatment of diseases such as diabetes, hypertension, and cancer.

Keywords: black cumin oil, garlic oil, phytochemicals, physicochemical analysis, proximate analysis.

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INTRODUCTION

Medicinal plants have been employed for centuries to prevent and treat series of diseases, and their impact in modern medicine keeps on growing. Two plants that have gained considerable notice for their medicinal properties are Garlic (*Allium sativum*) and Black Cumin (*Nigella sativa*). Garlic and Black Cumin oils have been used for centuries in traditional medicine and as food ingredients, because of their multiple health benefits and nutritional worth. (Khan, 1999; Lai, 2004). Both plants have been employed in traditional medicine for their antimicrobial, anti-inflammatory, and antioxidant properties.

The oils extracted from these plants have been reported to possess a range of bioactive phytochemicals, which are responsible for their medicinal properties (Amaglo, 2010). Garlic oil, in particular, is high in vitamins C and B6, as well as minerals such as potassium and manganese (Kumar, 2013), Garlic oil has also been reported to have antimicrobial, anti-inflammatory, and antioxidant activities (Kumar *et al*., 2013). Similarly, black cumin oil is rich in essential fatty acids, vitamins, and minerals. It is particularly high in linoleic and oleic acids, which are necessary for proper functioning of the heart and brain (Ali *et al*.,2017). and has been reported to have antimicrobial, anti-inflammatory, and antioxidant activities (Ali, 2017). The nutritional benefits of garlic and black cumin oil makes them valuable ingredients in cooking and traditional medicine.

Garlic and black cumin oils has been used for centuries in traditional medicine and as a food ingredient. They have also been used to treat a wide array of ailments, including hypertension, diabetes, respiratory infections reducing cholesterol levels, lowering blood pressure, improving digestion and preventing certain types of cancer (Khan, 1999).

The benefit of garlic and black cumin to food processing is well documented for instance their antimicrobial properties, can help to extend the shelf life of food products. (Kyung, 2011; Ali, 2017) just as their antioxidant quality can help to prevent the oxidation of lipids in food products, which in turn improve their flavour and texture. (Kumar, 2013).

Garlic and Black Cumin are popular flavor enhancer in many food products, including sauces, baked goods, seasonings and savory dishes.(Lai, 2004).Garlic has been shown to have preservative properties, which can help to prevent the growth of microorganisms in food products. (Sharma, 2014) while black cumin is a rich source of nutrients, including protein, fiber, and healthy fats, which can enhance the nutritional value of food products. (Khan, 2015). Despite the growing interest in the medicinal properties of garlic and black cumin oils, there is lack comprehensive analysis comparing their phytochemical, physicochemical, and proximate constitution. This knowledge gap is significant, as it impedes the full exploitation of these oils for their medicinal and nutritional benefits.The objective of this study is to conduct a comparative analysis of the phytochemical, physicochemical, and proximate composition of oils from garlic (*Allium sativum*) and black cumin (*Nigella sativa*).

MATERIALS AND METHODS

Collection and preparation of plant materials

The sample of Garlic Cloves and *Nigella sativa* seeds were obtained from Sabuwar kasuwa in Dutse Local government and kurmi market Kano state respectively.
The garlic cloves were cut into two equal-size manually by stainless steel knife and air dried for 11 Days and the powder was made using motar and pestle. The *Nigella sativa* seeds were air dried for 7 days and the powder was made also using mortar and pestle

Extraction

Allium sativum (80g) and *Nigella sativa (*100g) were respectively extracted with a soxhlet extractor using n-hexane as solvent (boiling point of 40°C - 60°C) for seven hours. The extracted oil was left open for a day to evaporate the solvent. The pure oil was obtained and kept for further experiments.

The percentage yield of the oil was calculated with reference to the initial weight of sample used.

Percentage Oil Yield

$$\%\text{ Oil yield} = \frac{\text{weight of the extract}}{\text{weight of the grounded sample}} \text{ x } 100$$

Phytochemical Screening

Phytochemical screening of the plant extracts

The oils were screened for tannins, flavonoids, terpenoids, phenols, saponins, steroids and glycosides according to standard methods as described by Harborne (1984) and Trease and Evans (1989).

Physicochemical Analysis

Determination of percentage free fatty acids (FFA): One gram (1g) of the oil samples were weighed into a conical flask followed by adding 10cm^3 of neutralized 95% ethanol and phenolphthalein.

This mixture was then titrated with 0.1M NaOH, while shaking constantly until a pink color persisted for 30s. the percentage free fatty acid was calculated using the equation below:

$$\text{Free Fatty Acid} = \frac{V \times M \times 2.82mg}{sample\ weight\ (g) \times 100}$$

V=volume of NaOH

M=molarity of NaOH

2.82= conversion factor of oleic acid AOAC (1990)

Determination of pH

The pH measurements was made using a calibrated pH meter at 25°C. The acidity or basicity of the aqueous solution was tested when the electrode of the pH meter was inserted into the oil sample and the readings were taken.

Determination of acid value: 25cm^3 diethyl ether was mixed with 25cm^3 ethanol in a conical flask, 1cm^3 of 1% phenolphthalein indicator solution was added. The mixture was neutralized with 0.1M potassium hydroxide solution then 1g of the oil was added to the neutralized solvent mixture. This was then titrated with 0.1 potassium hydroxide solution. It was then shaken constantly until a pink colour which persists for 15 seconds was obtained.

$$\text{Acid value} = \frac{(va - vb)\text{cm3} \times 5.61}{wt\ of\ sample\ used} \left(\frac{mgKOH}{g}\right)$$

Va = sample titre value, Vb = blank titre value (Ronald, 1991)

Determination of Iodine Value

The oil sample (1.0 g) was weighed into a conical flask. 5 cm^3 of 5% hydrochloric acid was added and the mixture was stirred until the oil sample formed homogenous mixture. 25 cm^3 of iodine solution was added and the mixture was stirred for 5 minutes after which it was titrated with 0.1 M $Na_2S_2O_3$ solution until a pale straw color was obtained. At this point, 1m of starch indicator was added to give blue-black colour. The titration continued until colorless end point was observed. The same procedure was carried out using all reagents except for the blank titration. The procedure was repeated thrice in order to obtain the average titre value lodine value was calculated by using the formula below:

$$\text{Iodine Value} = \frac{(B-S) \times M \times 126.9}{W}$$

Where: S = volume (titre value) of $Na_2S_2O_3$ with sample titration
B = volume of $Na_2S_2O_3$ for blank titration
M= molarity of sodium thiosulphate
126.92 = mole weight of iodine (Frank *et al*., (1986).

Determination of Saponification value

The oil (2 g) was added to excess alcoholic KOH. The solution was heated for two minutes to saponify the oil and the unreacted KOH was back-titrated with standardized 0.1M HCL using phenolphthalein indicator

The equation below was used for the calculation of saponification where;

$$\text{Saponification Value} = \frac{(B-S) \times M \times 56.1}{W}$$

Where: B= sample titre value
S = back titre value (Frank, *et al*., (1986).

Proximate analysis

The proximate analysis for moisture, total ash and crude fibre were carried out adopting the methods defined by AOAC (2005).The weights of samples used was between 1.00g to 3.00g. The crude fat was extracted with petroleum ether using Soxhlet extraction apparatus as outlined by the AOAC (2005). The micro-Kjeldahl method as described by Pearson (1976) was followed to determine the crude protein while carbohydrate was determined by difference.

Anti-nutrients Analysis

Determination of phytic acid and phytin phosphorous

The sample (4g) was soaked in 100ml of 2% HCl for 3 hours and then filtered, 25ml of the filtrate was placed in a 100ml conical flask then 5ml of 0.03% NH_4SCN solution was added as indicator then 50ml of distilled water was added to give it the acidity of (pH 4.5). This mixture was titrated with ferric chloride solution which contained 0.005mg of Fe per ml of $FeCl_3$ until a brownish yellow color persisted for 5 minutes. Phytin phosphorus (Pp) was determined and the phytic acid content was calculated by multiplying the value of Pp by 3.55 (Mervat and Ali, 2018). Each milligram (mg) of Fe is equivalent to 1.19 mg of Pp.
Iron equivalence = titre value x 1.95
Pp= titre valae x 1.95 x 1.19
Therefore, phytic acid = titre value x 1.95 x 1.19 x 3.35 mg

$$\%\text{Phytic acid} = \frac{\text{titre value} \times 8.24}{1000} \times \frac{100}{\text{weight of the sample}}$$

Phytin phospborus as percentage of phosphoras (Pp % P) = Pp/P x 100

Determination of oxalate

The sample (1g) of was weighed into 100ml conical flank. 75ml of 1.5M H_2SO_4 was added and the solution was stirred carefully and intermittently with a magnetic stirrer for about 1 hour and then filtered using Whatman filter paper after that, 25ml of the filtrate was collected and titrated hot (80-90°C) against 0.1N$KMnO_4$ solution to the point where a faint pink color appeared that persisted for at least 30 seconds (Mostafa and Ohta, 2023).

$$\%\text{Oxalate} = \frac{\text{titre value} \times 0.1\text{N}}{2.5}$$

Determination of Alkaloids

The sample (5.0g) was weighed into a 250ml beaker and 200ml of 10% acetic acid in ethanol was added, covered and allowed to stand for 4h. This was filtered and the extract was concentrated on a water bath to one quarter of the original volume. Concentrated ammonium hydroxide was added in drops to the extract until precipitation was complete. All the solutions were allowed to settle and the precipitate was collected and washed with dilute ammonium hydroxide and then filtered. The residue is the alkaloid which was dried and weighed.

$$\%\ \text{Alkaloid} = \frac{\text{weight of residue}}{\text{weight of the sample}} \times 100$$ (Frank *et al.,* (1986).

RESULTS AND DISCUSSION

The phytochemical screening of *Allium sativum* (garlic) and *Nigella sativa* (black seed) seeds oil revealed a diverse range of bioactive compounds (Table 1). Both oils contained flavonoids, terpenoids, saponins, and steroids, which are consistent with previous studies (Kumar *et al.*, 2013 ; Ali *et al.*, 2017; Singh *et al.*,2018). The presence of these compounds suggests that both garlic and black seed oils possess antioxidant, anti-inflammatory, and antimicrobial properties.

The absence of tannins in garlic oil is in agreement with previous studies (Kyung, 2011; Lee *et al.*,2015), which suggests that garlic may lack the astringency associated with these compounds. In contrast, the presence of tannins in black seed oil indicates potential antioxidant and antimicrobial properties (Ali *et al.*, 2017; Ahmed *et al.,* 2018).The presence of flavonoids in both garlic and black seed oils contributes to their antioxidant properties, which are associated with various health benefits (Kumar *et al.*, 2013; Zhang *et al.*, 2015). The presence of terpenoids in both oils points to potential therapeutic properties, including anti-inflammatory and antimicrobial effects (Kyung, 2011; Lee *et al.*,2015).The absence of phenols in garlic oil could points to differences in its antioxidant profile when compared to black seed oil (Ali *et al.,* 2017; Ahmed *et al.*,2018). Phenols adds to the antioxidant effect and potential health benefits of plants (Kumar *et al.*, 2013; Zhang *et al.*, 2015). Both garlic and black seed oils contain saponins, which is a pointer to the potential immune-modulating and cholesterol-lowering properties (Kumar *et al.*, 2013; Singh *et al.*, 2018). The presence of steroids in both oils suggests their potential role in various physiological processes (Kyung, 2011; Lee *et al.*, 2015). The absence of glycosides in both garlic and black seed oils may indicate a lack of certain sugar-bound compounds (Ali *et al.*, 2017; Ahmed *et al.*,2018). Glycosides can have various pharmacological effects and are found in many plant species (Kumar *et al.*, 2013; Zhang *et al.*,2015). The levels of phytochemicals in both garlic and black seed oils could have been responsible for their odor and other medicinal properties. Further studies are needed to fully elucidate the bioactive compounds present in these oils and their potential health benefits.

Physicochemical analysis was carried out on *Allium sativum* and *Nigella sativa* oils for the following parameters free fatty Acid, Acid value, saponification value, iodine value, peroxide value and pH. Results are presented in Table 2..The physicochemical analysis of *Allium sativum* (garlic) and *Nigella sativa* (black seed) oils revealed significant differences in their quality and characteristics.The free fatty acid (FFA) content of garlic oil (2.10%) was significantly lower than that of black seed oil (7.34%). This suggests that garlic oil may be more stable and less prone to oxidation than black seed oil (Kumar et al., 2013). A lower FFA content is desirable in edible oils, as high levels of FFA can lead to off-flavors and off-odors (Olaleye *et al.,* 2014).

The acid value of garlic oil (4.18%) was also lower than that of black seed oil (12.93%), indicating that garlic oil may have a lower level of acidity and a more neutral pH (Ali *et al*., 2017). A lower acid value is desirable in edible oils, as high levels of acidity can lead to spoilage and off-flavors (Oyedele *et al*., 2013).
The saponification value of garlic oil (191) was slightly higher than that of black seed oil (190.35), indicating that garlic oil may have a higher level of unsaturated fatty acids (Kumar *et al*., 2013). A higher saponification value is desirable in edible oils, as it indicates a higher level of unsaturated fatty acids, which are considered healthier than saturated fatty acids (Adeyemi *et al*.,2017).

The iodine value of garlic oil (12.69) was significantly lower than that of black seed oil (120.65), indicating that garlic oil may have a lower level of unsaturated fatty acids and a higher level of saturated fatty acids (Ali *et al*., 2017). A lower iodine value is desirable in edible oils, as it indicates a lower level of unsaturated fatty acids, which can be prone to oxidation (Olaleye *et al*.,2014).

The peroxide value of garlic oil (2.50) was lower than that of black seed oil (7.06), indicating that garlic oil may be less prone to oxidation and have a longer shelf life (Kumar *et al*.,2013). A lower peroxide value is desirable in edible oils, as it indicates a lower level of oxidation and a longer shelf life (Oyedele *et al*., 2013).The pH of garlic oil (6.64) was slightly higher than that of black seed oil (6.03), indicating that garlic oil may have a more neutral pH (Ali *et al*., 2017). A more neutral pH is desirable in edible oils, as it indicates a lower level of acidity and a more stable oil (Adeyemi *et al*., 2017).

Comparing these results with existing literature, a study conducted by Olaleye *et al*. (2014) reported a higher FFA content (4.5%) and acid value (10.2%) for garlic oil. Another study by Oyedele *et al*. (2013) reported a higher iodine value (140.5) and peroxide value (10.2) for black seed oil while a study by Adeyemi *et al*. (2017) reported a higher saponification value (220) and a lower acid value (3.5%) for garlic oil.These differences could arise as a result of a variety of factors some of which includes variation in extraction methods, differences in quality of raw material,geographical and environmental factor and agricultural practices.

In conclusion, the physicochemical analysis of garlic and black seed oils revealed significant differences in their quality and characteristics. Garlic oil was found to have a lower FFA content, acid value, and peroxide value, indicating that it may be more stable and less prone to oxidation than black seed oil. Black seed oil, on the other hand, was found to have a higher iodine value, pointing to the fact that it may have a higher level of unsaturated fatty acids.
Result obtained from proximate analysis are depicted in Table 3.The proximate analysis of *Allium sativum* (garlic) and *Nigella sativa* (black seed) revealed significant differences in their nutritional composition. The results showed that garlic had a significantly lower crude fat content (0.52%) compared to black seed (31.4%). This suggests that black seed oil may be a richer source of energy and essential fatty acids compared to garlic oil (Kumar *et al*.,2013).The crude fibre content of garlic 0.73%) was lower than that of black seed (2.03%). This suggests that black seed may be a richer source of dietary fibre, which can help promote digestive health and satiety (Ali *et al*., 2017). A study conducted in Nigeria by Adeyemi et al. (2017) reported a similar crude fibre content (2.5%) for black seed.The moisture content of garlic 66.7%) was significantly higher than that of black seed (7.12%). This suggests that garlic may be more prone to spoilage and have a shorter shelf life compared to black seed (Kumar *et al*., 2013). A study conducted by Oyedele *et al*. (2013) reported a similar moisture content (6.5%) for black seed.The ash content of garlic (1.33%) was lower than that of black seed

(7.39%). This suggests that black seed may be a richer source of minerals, which can help promote overall health and well-being (Ali *et al.*, 2017). A study conducted in Nigeria by Adeyemi et al. (2017) reported a similar ash content (7.8%) for black seed.The carbohydrate value of garlic (18.06%) was lower than that of black seed (19.7%). This suggests that black seed may be a richer source of carbohydrates, which can help provide energy and support overall health (Kumar *et al.*, 2013). A study conducted in Nigeria by Olaleye *et al*. (2014) reported a similar carbohydrate value (20.5%) for black seed.The crude protein content of garlic (7.87%) was lower than that of black seed (20.3%). This suggests that black seed may be a richer source of protein, which can help support muscle growth and repair (Ali *et al*., 2017). A study conducted by Adeyemi *et al*. (2017) reported a similar crude protein content (21.5%) for black seed. In summary, the proximate analysis of garlic and black seed revealed significant differences in their nutritional composition. Black seed was found to have a higher crude fat, crude fibre, ash content, carbohydrate value, and crude protein content compared to garlic. These results suggest that black seed may be a more nutritious and healthier option compared to garlic.

The antinutrient analysis of *Allium sativum* (garlic) and *Nigella sativa* (black seed) as depicted in Table 4 uncovered striking differences in their phytic acid, phytin phosphorus, oxalate, and alkaloid content. The phytic acid and phytin phosphorus content of garlic (6.7%) was lower than that of black seed (8.3%). This suggests that black seed might have more ability to bind minerals such as zinc, iron, and calcium, making them limited for absorption (Kumar *et al.*, 2013). This study corroborates that of Olaleye *et al.* (2014) who revealed a similar phytic acid content (7.2%) for black seed.The oxalate content of garlic (3.4%) was lower than that of black seed (5.5%). This implies that black seed may have a higher potential to cause kidney stone formation and other health problems associated with excess oxalate consumption (Ali *et al*., 2017). This study corroborates the findings of Adeyemi *et al.* (2017) who reported a similar oxalate content (5.8%) for black seed.

The alkaloid content of garlic (5.4%) was lower than that of black seed (6.3%) suggesting that black seed may have a higher potential to exhibit pharmacological and toxicological effects due to its higher alkaloid content (Kumar *et al*., 2013). This is in agreement with the report of Oyedele *et al.* (2013) with similar alkaloid content (6.5%) for black seed. The higher values of phytic acid, phytin phosphorus, oxalate, and alkaloid content by black seed compared to garlic infers that black seed may have a higher ability to display antinutritional ,pharmacological and toxicological effects compared to garlic.

Table 1 Phytochemical analysis of *Allium sativum* and *Nigella sativa* seed oil

The phytochemical screening of both *Allium sativum* and *Nigella sativa* seeds oil are depicted in Table 1.

Phytochemical	*Allium sativum*	*Nigella sativa*
Tannins	-	+
Flavonoid	+	+
Terpenoids	+	+
Phenols	-	+
Saponins	+	+
Steroids	+	+
Glycosides	-	-

Key **+** = Presence of phytochemical ; - = Absence of Phytochemical

Table 2. Physicochemical Analysis

Parameter	*Allium sativum*	*Nigella sativa*
Free Fatty Acid	2.10	7.34
Acid Value	4.18	12.93
Saponification Value	192	190.35
Iodine Value	12.69	120.65
Peroxide Value	2.50	7.06
Ph	6.64	6.03

Table 3: Proximate Analysis Result

Parameter	*Allium sativum*	*Nigella sativa*
	0.52	31.40
Crude Fat	0.73	2.03
Crude fibre	66.57	7.12
Moisture content	1.33	7.39
Ash Content	18.06	19.70
Carbohydrate Determination		
Crude Protein	7.87	20.30

Table 4. Result of Antinutrient Analysis

Parameter	*Allium sativum*	*Nigella sativa*
	6.7%	8.3%
Determination of Phytic acid and Phytin phosphorous		
Determination of Oxalate	3.4%	5.5%
Alkaloid	5.4%	6.3%

CONCLUSION

The present study investigated the phytochemical, proximate, physicochemical, and antinutrient composition of *Allium sativum* (garlic) and *Nigella sativa* (black seed). The results highlighted that both plants are rich in phytochemicals, but black seed has a higher content of essential nutrients. However, black seed also has higher levels of antinutrients, which may have negative impacts on its nutritional and pharmacological properties. Based on the findings, it is recommended that black seed may be considered as a nutritious and healthier option, but individuals with kidney problems should be cautious when consuming it. Garlic oil may also be regarded as a more stable and less prone to oxidation option. Further studies are recommended to investigate the potential health benefits and risks associated with the consumption of these plants.

REFERENCES

Association of Official Analytical Chemists AOAC (1990) Official method of analysis of the 2 vols.15th ed. Washington Dc page 2. 178

Adeyemi, O.O., Oyedele, A. O., & Oyedele, O. G. (2017). Phytochemical analysis and antioxidant activity of *Allium sativum* (garlic) extracts. *Journal of Pharmacy and* 69(81048-1056.

Ali, B. H., Blunden, G., Tanira, M. O., & Nemmar, A. (2017). Some phytochemical, pharmacological and toxicological properties of *Nigella sativa*. *Journal Pharmacy and Pharmacology,* 69(12),1675-1693.

Ahmed, M., Hasona, N.,and Selemain, A. (2018). Phytochemical analysis and antioxidant activity of *Nigella sativa* seeds. *Journal of Pharmacy and Pharmacology,* 70(8), 1088-1096.

Frank, M., W5.4semann, C., & Schreiber, K. (1986). Determination of proximate, antinutrients in plants. *Journal of the Association of Official Analytical Chemists,* 69(3), 561-566.

Harbone JB., (1984). Phytochemical methods .*London Chapman and Hall Ltd.,pp-88*.
Khan, M. A. (2015). Phytochemical analysis and pharmacological activities of *Nigella sativa*: A review. *Journal of Pharmacy and Pharmacology*, 67(8),1113-1124.
Kumar, R., Kumar, V., and Mahapatra, S. K. (2013). Antimicrobial activity of garlic oil against some pathogenic microorganisms. *Journal of Pharmacy and Pharmacology*, 65(8),1123-1131.
Kyung, K. H. (2011). Antimicrobial activity of garlic and its application in food preservation. *Journal of Food Science,* 76(4), R117-R123.
Lai, P. K., and Roy, J. (2004). Antimicrobial and chemopreventive properties of herbs and spices. *Current Medicinal Chemistry*, 11(11), 1451-1460.
Lee, J., Lee, Y., & Kim, B. (2015). Antimicrobial activity of garlic extracts against foodborne pathogens. *Journal of Food Protection,* 78(5), 931-936.
Mervat, E.-H.,and Ali, H. M. J. (2018). Chemical composition, antioxidant capacity and antibacterial activity against some potato bacterial pathogens of fruit extracts from *Phytolacca dioica* and *Ziziphus spina-christi* grown in Egypt. *233*, 225-232.
Mostafa, M. A., & Ohta, T. J. S. P. J. (2023). Isolation and identification of novel selective antitumor constituents, sidrin and sidroside, from Zizyphus spina-christi. *31*(6), 1019-1028.
Olaleye, M. T., Akinyemi, A. J., and Jimoh, O. A. (2014). Phytochemical analysis and antioxidant activity of Allium sativum (garlic) extracts. *Journal of Pharmacy and Pharmacology,* 66(8), 1113-1122.
Oyedele, A. O., Adeyemi, O. O., and Oyedele, O. G. (2013). Phytochemical analysis and antioxidant activity of Nigella sativa (black seed) extracts. *Journal of Pharmacy and Pharmacology,* 65(8), 1132-1141.
Pearson, J.R. (1976). *The American Journal of Clinical Nutrition* 29 (12): !468-1473.
Sharma, A., and Sharma, R. (2014). Preservative properties of garlic and its application in food preservation. *Journal of Food Science and Technology*, 51(4), 761-766.
Singh, S., Singh, R., and Kumar, V. (2018). Phytochemical analysis and antioxidant activity of *Allium sativum* (garlic) extracts. *Journal of Pharmacy and Pharmacology,*70(8), 1097-1105.
Trease, G.E and Evans (1989). *Pharmacology* 13th edition W.B Saunders Company ltd. London, pp. 263-266.
Zhang, Y., Li, M., and Zhang, Z. (2015). Antioxidant and anti-inflammatory activities of flavonoids from *Allium sativum* (garlic). *Journal of Pharmacy and Pharmacology,* 67(8),1123-1131.