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Physicochemical Properties, Antibacterial and Antifungal Potential of Pumpkin Seeds (*Telfairia occidentalis*) Oil in Tomato Puree

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ABSTRACT

This study evaluated the physicochemical properties, antibacterial and antifungal potential of pumpkin (*Telfairia occidentalis*) seed essential oil in tomato puree. The essential oil was extracted using steam distillation and analyzed using standard methods. The oil yield was 16.20 %, with a specific gravity of 0.92, viscosity of 0.17 cp, refractive index of 1.475, density of 6.17 g/ml, iodine value of 108.70 gI2/100g, saponification value of 170.00 mg/KOH, peroxide value of 17.20 meqO2/kg, acid value of 32.50 mg/KOH, and free fatty acids value of 43.77 %. The analysis revealed flavonoid, phenol, vitamin A, and vitamin E contents of 18.90, 12.20, 30.78, and 40.90 mg/g, respectively. These results indicated the oil's good quality, high unsaturation, and potential edibility. After four weeks of storage at room temperature, the oil demonstrated significant preservative effects in tomato puree. Bacterial and fungal counts decreased in samples treated with varying oil quantities (0.1–0.7 mL) compared to the untreated control. The sample with the highest oil quantity (0.7 ml) showed minimal bacterial (9.53×10^3 cfu/mL) and fungal (10.00×10^2 cfu/mL) proliferation. Despite an overall microbial increase over time, counts remained within safe limits. Thus, pumpkin seed oil has preservative potential and may be a natural alternative to synthetic preservatives in food products.

Keywords: Antibacterial and antifungal potential, physicochemical properties, pumpkin seed oil, tomato puree.

INTRODUCTION

Pumpkin (*Cucurbita moschata*) seeds are nutrient-dense seeds obtained from pumpkins. A 28g serving of unshelled, unsalted pumpkin seeds provides about 163 calories, 8.5g protein, 14g fat (mostly unsaturated), 4.2 g carbohydrate, 156 mg magnesium, 2.3 mg iron, 2.2 mg zinc, 223 mg potassium, 333 mg phosphorous, 0.4 mg copper, and 14.7 mg calcium (Kathi, 2025). They have the potential to lower prostate cancer risk (Kathi, 2025), improve prostate health and heart health (Harvard, 2023), sleep improvement (Kathi, 2025), improve immune systems, reduce inflammation, and the risk of diabetes (Xue *et al.,* 2019) because they are high in antioxidants, vitamins, minerals, and bioactive compounds. Pumpkin seeds can be eaten as a snack, in smoothies, and incorporated into baked products and salads. Adding pumpkin seeds to the diet or processed foods is a great way to increase consumption. Studies have reported their antibacterial and antifungal properties, making them suitable candidates for food preservation (Nkosi et al., 2006; Rezig et al., 2012).

The use of synthetic preservatives in food processing has raised safety and health concerns due to potential adverse effects such as toxicity, allergies, and carcinogenicity, especially with butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) (Carly, 2024). Consequently, there is a growing demand for natural alternatives to synthetic chemicals (Gyawali and Ibrahim, 2014).

Tomato (*Solanum lycopersicum*) is a nutrient-rich fruit commonly used as a vegetable in culinary applications and belongs to the nightshade family, widely cultivated for its edible fruits, which are consumed fresh or processed into various products like tomato paste, puree, and ketchup (Adda, 2023). The understanding that fresh tomatoes are a seasonal product in Nigeria has led to an increase in the production of tomato puree. During the rainy season, tomato production declines, leading to significant price increases of over 200% in some regions (Ekundayo, 2024). Fresh tomatoes have a limited shelf life and are prone to spoilage due to high moisture content. Processing them into puree reduces their water content and eliminates factors contributing to decay, thereby extending their usability. This helps to enjoy tomato-based products beyond the natural growing season (Elizabeth, 2024). Processing fresh tomatoes into tomato puree not only boosts the nutritional value and shelf life but also adds significant convenience and versatility to culinary practice (Xianli et al., 2021). Tomato puree is a concentrated form of tomatoes, created by cooking and straining fresh tomatoes to remove seeds and skins, resulting in a thick paste. It is widely used in culinary applications such as stews, sauces, soups, and casseroles to enhance flavour and colour. There is a significant global market growth for tomato puree, valued at $5.2 billion in 2022 and projected to reach $7.7 billion by 2032 due to the increased rate of population and urbanization (Tomato puree market, 2024).

Despite the mentioned potentials, limited research has been conducted to evaluate pumpkin seed oil as a natural preservative in food systems like tomato puree. Thus, the evaluation of the physicochemical, antibacterial, and antifungal properties of pumpkin seed oil (*Cucurbita moschata*) in tomato puree.

MATERIALS AND METHODS

Source of materials

The pumpkin (*Cucurbita moschata*) seed and fresh tomatoes used in this study were purchased from Eke-Awka Market in Awka (Latitude 6° 12′ 22.92″ N and Longitude 7° 4′ 5.36″ E) Anambra state. All chemicals used were sourced from head bridge Onitsha Anambra State, Nigeria.

Extraction of seed oil and oil yield

The steam distillation method described by Basma and Abdul-Majeed (2013) was used in the extraction of the seed oil. 500 g of the finely ground samples were placed into a necked round extraction flask and soaked with 700 mL of water. The flask was fitted with a rubber stopper connected to a condenser and heated using a hot plate. Water and samples were mixed and allowed to boil. Water and extracted essential oil evaporated. The water at 0°C flowed countercurrently through the condenser to condense the steam. When the samples were heated up, the essential oil that was extracted from them was mixed with the water vapour. Both passed through the condenser, and the vapour was condensed into liquid. The volatilization of the essential oil was avoided by cooling with the use of cold water. The condensate was directly collected using a 500 mL beaker and then poured into a separating funnel. This formed two layers of oil and water. The tap of the separating funnel was then opened to let out the water while the oil was immediately collected into a 100 mL stopper bottle. The bottle was closed to prevent the vaporization of the essential oil. The oil was then collected, and the volume of oil obtained was weighed. The percentage oil yield of the samples was calculated as follows:

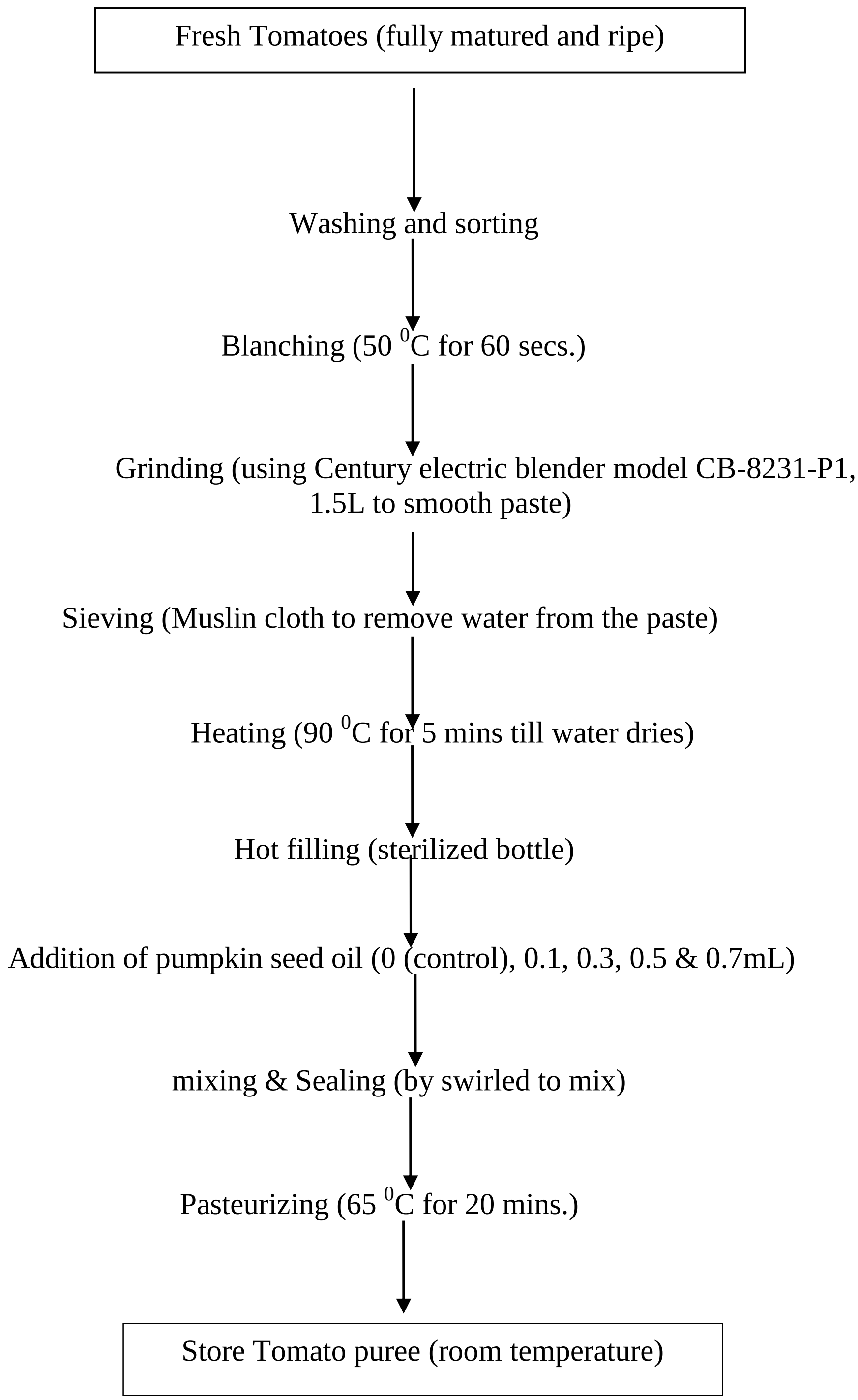
$$\%\text{ yield of oil} = \frac{\text{Weight of oil}}{\text{Weight of sample}} \times 100\%$$

Chemical analysis Determination of saponification value

The saponification value, iodine value, specific gravity, density, refractive index, and viscosity were determined using AOAC (2000), free fatty acid (Aletor et al., 1990), peroxide value (AOAC, 1990), acid value with ISO 660:1996 (International Organization of Standardization, 1996), total phenolic (Folin-Ciocalteu method by Medini et al., 2014), total flavonoid (Djeridane et al., 2006), vitamin A (Goudoum et al., 2002), and vitamin E (Krishnaiah et al., 2002).

Experimental design, production, and preservation of tomato puree with pumpkin seed oil

A completely randomized mixture design was used for the preservation of the sample while the tomato puree was produced according to the method described by



Flowchart 1. Production and preservation of tomato puree with pumpkin seed oil.
Source: Folinas et al. (2011) and Olusanya (2001).

Folinas et al. (2011) and Olusanya (2001) as shown in the Flowchart 1. The essential oil was added in the ratio of 0, 0.1, 0.3, 0.5 and 0.7 against 300 mL of tomato puree for each, respectively.

Percentage of Pumpkin seed oil yield

This was calculated by the use of the formula as stated by the AOAC (2005).

$$\% \text{ Oil Yield} = \frac{\text{Volume of the oil produced}}{\text{Weight of the pumpkin seed}} \times 100$$

Volume of the oil produced = 81 mL, Weight of the seed Density = 500

Total bacterial and fungal count of the stored preserved tomato puree

The samples were serially diluted using sterile distilled water as diluents. Then, 9 mL of distilled water was measured out into test tubes, using separate sterile pipettes, and 1 mL of the sample was measured out into the first test tube and properly mixed. Using a different sterile pipette, 1 mL from the first test tube was pipette into the second test tube already containing 4 mL of distilled water; this continued following the same procedure till the last dilution.

The pour plate was done according to Cowan (2005). Aliquots of 1 mL of 10^{-3} dilutions were inoculated on nutrient agar in duplicate using the spread plate method. The plate was incubated at 37°C for 24 hours. After incubation, the colonies on the plate were counted using a manual colony counter, and the number of cells per mL of the sample was recorded.

Statistical Analysis

The data obtained using triplicate determinations was subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Scientists (SPSS) version 21.0. The means were separated using the Duncan Multiple Range Test at a 95% confidence level.

RESULTS AND DISCUSSION

Percentage oil yield and physicochemical properties of Pumpkin seed oil

The percentage oil yield and physicochemical properties of pumpkin seed oil are shown in Table 1. The percentage yield of the oil is relatively low (16.2 %), especially when compared to values of 48.00 % and 46.40 % reported by Mohammed and Hamza (2008) and Sani et al. (2013), respectively. The variation in these results might be a result of differences in the climate of the cultivation area, species used (*Cucurbita pepo* yields more oil than *Cucurbita maxima*), type of soil, stage of maturity, harvesting time, or the oil extraction method used (Nichols and Sanderson, 2003).

Table 1. Percentage Oil Yield and Physicochemical Properties of Pumpkin Seed Oil.

Parameters	Values
Percentage oil yield (%)	16.2±0.0
Specific gravity (cp)	0.92±0.01
Density (kg/mL)	6.17±0.01
Viscosity (cp)	0.17±0.01
Refractive index (u)	1.48±0.1
Saponification value (mg/KOH)	170±0.0
Iodine value (mg/g)	108.7±0.2
Acid value mg/KOH)	32.5±0.0
Peroxide value (meq/kg)	17.20±0.01
Free fatty acid (%)	43.8±0.02

Values are means ± standard deviation of triplicate determination.

The specific gravity of the pumpkin seed oils is 0.92 cp and is within the range of 0.903-0.926 and 0.9159 reported by Nichols and Sanderson (2003) and Markovic and Bastic (2005), respectively, for *Curbita. pepo*. This value also fell in the range reported for olive (0.910-0.920), coconut (0.908-0.921), rapeseed (0.910-0.920), and canola (0.914-0.920) oils (Nichols and Sanderson, 2003).

The density of the pumpkin seed oil was found to be 6.17 kg/mL. The value indicated that the pumpkin seed oil had a high density when compared with coconut (0.925 kg/mL) and cottonseed (0.925 kg) oils.

The viscosity of the pumpkin seed oil is 0.17 cp, which is lower than those reported by Tsaknis et al. (2007) for *C. pepo* (72.00 cP) and Alfawaz (2004) for *C. maxima* (48.09 cp). Wazed et al. (2023) reported a viscosity range of 33.24 to 48.43mpa.s for soybean, palm, mustard seed, and bran oil. Viscosity is related to the chemical properties of the oil, such as chain length and saturation or unsaturation. An increase in viscosity may be probable due to the high saturation of the triglyceride chain, whereas the decrease is likely due to an increase in unsaturation (Santos et al., 2014). This implies that the pumpkin seed oil is probably very high in the degree of unsaturation, making it a very healthy oil, but it may be very unstable in storage. It can also be used to evaluate the quality of fats and oils used in frying (Nichols and Sanderson, 2003).

The pumpkin seed oil showed a refractive index of 1.48 u, which is within the value reported by Lazos (2006) for pumpkin (1.4616) and melon (1.4662) seed oils. It is also within the range of values (1.45 to 1.47) reported by Wazed et al. (2023) for soybean, palm, mustard seed, and bran oil. Refractive index is used by most processors to measure the change in unsaturation as the fat or oil is hydrogenated. The refractive index of oils depends on their molecular weight, fatty acid chain length, degree of unsaturation, and degree of conjugation (Nichols and Sanderson, 2003). The saponification value of the pumpkin seed oil is 170.00 mg/KOH oil and is below the

Table 2. Phytochemical and Vitamin Content of Pumpkin Seed Oil in mg/g.

Parameters	Values
Flavonoids	18.9±0.2
Phenolic	12.20±0.10
Vitamin A	30.78±0.01
Vitamin E	40.90±0.05

Values are means ± standard deviation of triplicate determination.

value of 174-200 mg/KOH reported for the pumpkin seed oils by Nichols and Sanderson (2003) but higher than the value of 132.3 mg/KOH reported by Younis et al. (2000) for *Cucurbita* species. Furthermore, it fell in the range reported for olive (162 mg/KOH), canola (173 mg/KOH), corn (168 mg/KOH), and sunflower (183.2 mg/KOH) oils (Nichols and Sanderson, 2003). However, the value obtained was below the expected range of 195-205 mg/KOHg for the saponification value of edible oil as specified by the Standard Organisation of Nigeria (SON) and Nigerian Industrial Standards (NIS) 1992, as reported by Wazed et al. (2023). The low value of saponification value suggests the presence of glycerides with the highest molecular weights (Wazed et al., 2015). It is an index of the average molecular mass of fatty acids, and it is used in checking adulteration of the oil samples (Zahir et al., 2017). This value indicated that the pumpkin seed oil has fatty acids with a higher number of carbon atoms (Nichols and Sanderson, 2003). This connotes that the oil is in a crude state and unrefined.

The pumpkin seed oil had an iodine value of 108.70 mg/g, indicating high unsaturation. This value is close to 103.2, 107.0, and 105.1 mg/g reported by Lazos (2006), Tsaknis *et al.* (2007), and Alfawaz (2004), respectively, but lower than 123.0 mg/g reported by Younis et al. (2000) and 116.0-133.4 mg/g reported by Markovic and Bastic (2005) for *Cucurbita moschata* species. Also, Wazed et al. (2023) reported a value range of 46.18 to 133.1 mg/g iodine. Bwade et al. (2013) stated that iodine values of 104.99 to 108.4 gI2/100g indicated that pumpkin seed oil is a semi-drying oil, characterized by moderate unsaturation levels. This classification suggests that the oil has a balance between stability and reactivity, making it suitable for various culinary and industrial applications. The higher iodine value suggests that the oil will be less stable in normal conditions, while the lower the iodine value, the greater the oxidative storage stability.

Considering the content of free fatty acids (43.77 % as oleic acid), acid value (32.50 mg/KOHl), and peroxide value (17.20 meq/kg) in Table 1, the FFA value of refined oil is <0.05%, and the peroxide value is <1 meq/kg (Nurham, 2016). However, the oil produced from pumpkin seeds was not refined and could be said to be very high and should not be used in its crude state. This means that the extracted pumpkin seed oil had an unacceptable initial quality. The Codex Alimentarius Commission expressed the permitted maximum acid values of 10 and 4 mg KOH/g oil for virgin palm and coconut oils, respectively (Alfawaz, 2004). It has been shown that oils become rancid when the peroxide value is above the range of 20.0 to 40.0 meq/kg (Ajayi et al., 2006). This is an indication that the crude oil may be unfit for use in food preparation unless refined.

Phytochemical properties and vitamin content of pumpkin seed oil

The Phytochemicals an index of the antioxidant properties and the vitamins of the pumpkin seed oil, and is shown in Table 2. Antioxidants are compounds that protect cells against the damaging effects of reactive oxygen species, such as singlet oxygen, superoxide, peroxyl radicals, and peroxyl nitrile. An imbalance between antioxidants and reactive oxygen species results in oxidative stress, leading to cellular damage (Wong *et al*., 2008).

The result of the total flavonoid content of the pumpkin seed oil is 18.9 mg/g, and this is above the value of 139.37 catechin equivalents (CE) per 100g (1.3927mg/g) reported by Ashia et al. (2021), indicating a rich presence of flavonoids in the seed. The presence of flavonoids indicates the oil preservative potential in the food system as potent biological antioxidants (Wong et al*.,* 2008).

The total phenolic content of the pumpkin seed oil is 12.2 mg/g oil. Mikolajczak (2021) reported the range of 3.9 to 2360 mg/g for pumpkin seed oil, while Sunmonu et al. (2018) reported a value of 354.42 to 2047.29 mg/kg for tomato products. Recently, there has been an increasing interest in studying phenolic compounds from oilseeds, because they represent potentially health-promoting substances and have industrial applications. These naturally occurring compounds have proven to play an important role in the stability, sensory, and nutritional characteristics of food products and may prevent deterioration through quenching of radical reactions responsible for lipid oxidation (Siger et al., 2008).

The pumpkin seed oil had a vitamin A content of 30.78 mg/g while Raffaele et al. (2020) and Sunmonu *et al.* (2018) reported 90 to 150 mg/kg and 212.18 to 500.79 mg/kg of lycopene in tomato products. However, the value obtained is within the reported range of 30.23-45.12 mg/g for rice bran oil by Nakic et al. (2006). Vitamin A is essential for many processes in the body, including maintaining healthy vision, ensuring the normal function of the immune system and organs, and aiding the proper growth and development of babies in the womb (Nakic et

Table 3. Total Bacteria Count of Tomato Puree Preserved with Different Concentrations of Pumpkin Seed Oil in CFU/mL

Samples	Week 1	Week 2	Week 3	Week 4
0.1ml	3.84^b x10^3	8.30^b x10^3	16.80^b x10^3	12.80^b x10^3
0.3ml	3.80^b x10^3	8.27^b x10^3	15.00^c x10^3	10.91^c x10^3
0.5ml	2.00^c x10^3	8.00^c x10^3	14.33^d x10^3	10.12^d x10^3
0.7ml	1.70^d x10^3	8.00^c x10^3	11.18^e x10^3	9.53^e x10^3
0.0 ml (control)	5.70^a x10^4	8.80^a x10^4	17.88^a x10^4	15.80^ax10^4

Values are means of triplicate determination. Mean values in the same column with different superscripts are significantly different (P<0.05).

al., 2006). It also serves as an antioxidant with the capacity to prevent oxidation in food systems during storage.

Vitamin E (Tocopherol homologs) is an antioxidant that occurs naturally in vegetable oils and provides some protection against oxidation by terminating free radicals. The determination of tocopherol homologs in the seed oils is important owing to their antioxidative effects and their positive nutritional influences on human metabolism as biological antioxidants (Yoshida et al., 2006). The pumpkin seed oil had a total tocopherol of 40.90 mg/g (an appreciable quantity), which is in close range with a value of 43.27 mg /g obtained by Tsaknis et al. *(*2007). Vitamin E contributes to good oxidative stability of the oil during storage and processing.

Total bacterial and fungal count of Tomato puree preserved with different concentrations of pumpkin seed oil

The total bacterial count of the stored tomato puree preserved with different concentrations of pumpkin seed oil is shown in Table 3 and Figure 1. Generally, there was a significant difference (p<0.05) between the control sample (untreated tomato puree) when compared with the tomato puree preserved with different concentrations of pumpkin seed oil over the storage period of 4 weeks at room temperature. The bacterial count for the tomato puree (300 mL) preserved with different concentrations of pumpkin seed oil ranged from 1.70 to 16.80 x 103, while the untreated ranged from 5.70 to 17.88 x x104 over the storage period of 4 weeks. This indicated the preservative potential of the pumpkin seed oil over the tomato puree. An increasing trend in the total bacterial count with an increase in storage period was observed, except from week 3 to week 4, which declined across all the concentrations, including the control sample. The tomato puree preserved with 0.7 mL of the pumpkin seed oil had a lower total bacterial count than other samples preserved with 0.1, 0.3, and 0.5 mL. This means that the total bacteria count decreased with an increase in the pumpkin seed oil concentration used in the preservation and vice versa. This shows that the oil preservative potentials of the pumpkin seed oil are dose/concentration dependent. Tran et al. (2018) reported that the antimicrobial activity of the 4 edible oils on *S. aureus* and *E. coli* at 0.01 to 0.10 mg/mL had no marked difference in the *E. coli* as compared with the negative control, but at a higher dose of 0.05 mg/mL, 4 oils (soybean, cotton, flax, and sesame) exhibited remarkably higher inhibition than other oils and the negative control. The increased (week 1 to 3) and decreased (week 4) trend in the bacterial load of the stored tomato puree with pumpkin seed oil could be attributed to the principle of the bacteria growth curve, where within the initial first three weeks of the storage, the bacteria got acclimatized to the food product environment (lag phase), used up the available nutrient in the stored tomato puree to multiply (log phase)S while at the week 3, the stationary phase would have occurred leading to the decrease in bacterial load due to death phase as seen in the Table 3 (Madigan et al., 2012). The total bacteria count obtained from this project is below the maximum value of 40 x 103 (tomato puree) reported by Eleyowo and Amusa (2021) and within the acceptable limit of <105 CFU/g for bacteria (Olaniyi et al., 2010).

Table 4 and Figure 2 shows the total fungal count of the stored tomato puree preserved with different concentrations of pumpkin seed oil. The fungal count for the tomato puree preserved with different concentrations of pumpkin seed oil ranged from 1.99 to 14.24 x 102, while the untreated ranged from 2.88 to 16.17 x 102 over the storage period of 4 weeks. Generally, the total fungal count of all the samples (preserved and unpreserved) significantly increased (p<0.05) with an increase in storage period. At week 2 the samples preserved with 0.3, 0.5, and 0.7 mL had no significant difference (p > 0.05). Still, at weeks 3 and 4, the 0.7 mL concentration significantly reduced the total fungal count compared to other samples, both preserved and unpreserved. This significant reduction in the concentration of 0.7 mL is an indication that the preservative potential of the pumpkin seed oil is concentration-dependent. The continuous increase in the trend of the fungi load with an increase in

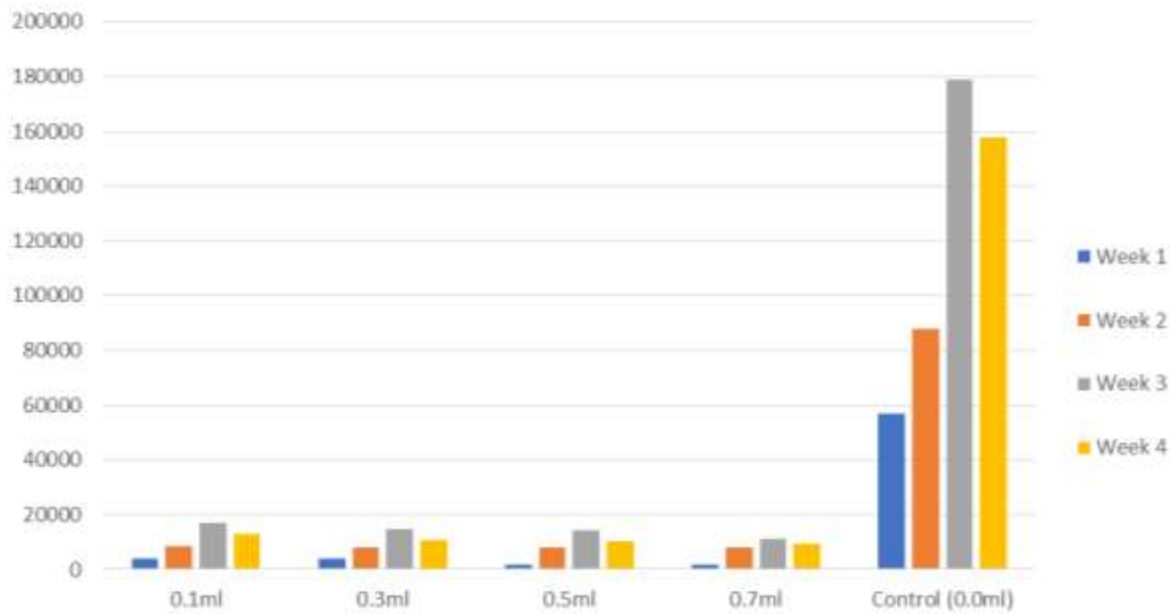


Figure 1. Total Bacteria count (CFU/mL) of tomato puree preserved with different concentrations of pumpkin seed oil.

Table 4. Total Fungal Count of Tomato Puree Preserved with Different Concentrations of Pumpkin Seed Oil in cfu/mL.

Samples	Week 1	Week 2	Week 3	Week 4
0.1ml	1.99^{b} x10^{2}	5.77^{b} x10^{2}	12.20^{b} x10^{2}	14.24^{b} x10^{2}
0.3ml	1.50^{c} x10^{2}	5.00^{c} x10^{2}	10.00^{c} x10^{2}	12.40^{c} x10^{2}
0.5ml	1.27^{d} x10^{2}	5.25^{c} x10^{2}	9.37^{d} x10^{2}	12.02^{d} x10^{2}
0.7ml	1.20^{e} x10^{2}	5.11^{c} x10^{2}	9.00^{e} x10^{2}	10.00^{e} x10^{2}
0.0 ml (control)	2.88a x102	6.80a x102	14.80a x102	16.17ax102

Values are means of triplicate determination. Mean values in the same column with different superscripts are significantly different (P<0.05).

the storage period of the tomato puree stored (4 weeks) with pumpkin seed oil could be attributed to the fact that tomato puree is a nutrient-rich medium, which is ideal for fungal growth. Pumpkin seed oil contains unsaturated fatty acids and vitamins, which can act as growth promoters for some fungi. Over time, the breakdown of cell walls in the puree releases more nutrients, further encouraging fungal proliferation (Olunkunle et al., 2008). The total fungi count obtained is below the maximum value of 69 x 103 (tomato puree) reported by Eleyowo and Amusa (2021) and within the acceptable limit of <103 to 104 CFU/g for fungi count (Olaniyi et al., 2010).

The total bacterial and fungal count was above the permissive limit for all samples, both preserved and unpreserved, according to WHO limits of 0 cfu/g (Eleyowo and Amusa, 2021). This could be attributed to the level of microbial load of the fresh tomatoes used due to harvesting, post-harvest handling, and processing (Adjo et al., 2015). It is also because fresh tomato fruits, being succulent with above 80 % water content, low in pH, and highly rich in nutrient elements and sugar, could serve as a suitable medium for microbial growth (Singh and Sharma, 2007).

CONCLUSION

The study revealed that the low yield of pumpkin seed oil makes it uneconomical for industrial or edible purposes. Despite this, the oil's unique physical properties, including high density and low viscosity, indicate it is highly unsaturated, potentially healthier, but less stable during

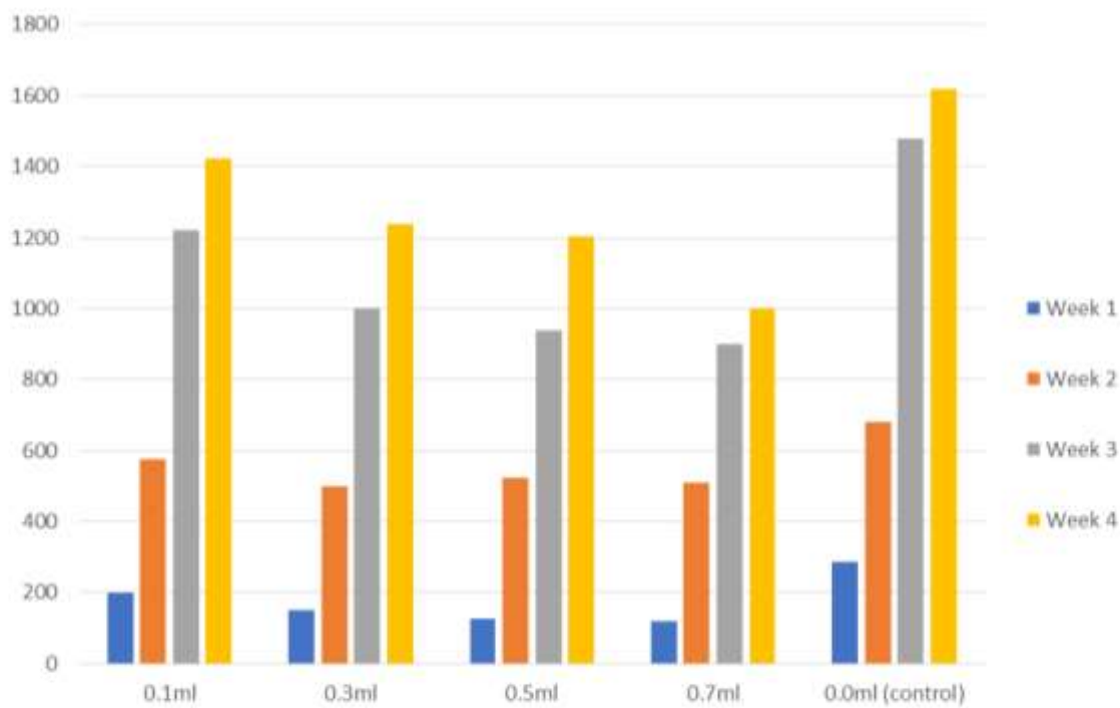


Figure 2. Total Fungal count (CFU/mL) of Tomato puree preserved with different concentrations of pumpkin seed oil.

storage. The refractive index and low saponification value reflect its natural, unrefined state, with high molecular weight glycerides contributing to its health potential. However, the crude oil's elevated free fatty acid, acid, and peroxide values suggest poor initial quality, necessitating refinement for safe consumption. The oil's significant content of flavonoids, phenolic compounds, vitamin A, and vitamin E highlights its antioxidant capacity and preservative qualities.

The tomato puree stored for four (4) weeks with 0.7 mL of pumpkin seed oil had the lowest bacterial and fungal count of 9.53 x 10 3 CFU/mL and 10 x 10 2 CFU/mL when compared with the control sample (untreated) 15.8 x 10 4 CFU/mL and 16.17 x 10 2 CFU/mL, respectively. This showed that the higher the quantity of pumpkin oil used, the lower the bacterial and fungal count.

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ETHICAL GUIDELINE

Ethics approval was not required for this research.

CONFLICT OF INTEREST

The authors declare no conflicts of interest

REFERENCES

Adda, B. (2023). Tomatoes 101: nutrition facts and health benefits.

Adejo, G. O., Agbali, F. A. and Otokpa, O. S. (2015). Antioxidant, Total Lycopene, Ascorbic Acid and Microbial Load Estimation in Powdered Tomato Varieties Sold in Dutsin-Ma Market. Open Access Library Journal 2:e1768.
http://dx.doi.org/10.4236/oalib.1101768

Ajayi, I. A., Oderinde, R. A, Kajogbola, D. O, and Uponi, J. I. (2006). Oil Content and Fatty Acid Composition of Some Underutilized Legumes from Nigeria. *Journal of Food Chemistry 9*(9): 115-120.

Aletor, V. A., and Ogunyemi, O. (1990). The performance, hematology, scrum constituents and economics of producing weaner-pigs on dried brewer's grain. *Nigerian Journal of Technology Research 2*(2): 85-89.

Alfawaz, M. A. (2004). Chemical Composition and Oil Characteristics of Pumpkin (*Cucurbita maxima*) Seed Kernels. *Journal of Food Science and Agricultural Research 3*(2): 5-18.

AOAC (1990). Official Methods of Analysis. Association of Official Analytical Chemists, Washington, D.C. 339.

AOAC (2000). Official methods of analysis, 17th ed. Association of Analytical Chemists, Washington, D.C.

AOAC (2005). Official Methods of Analysis. Association of

Official Analytical Chemists (9th edn), Washington, D.C.

Ashia, H., Tuskeem, K., Ahmad, D., Mian, A. M., Muhammad, A. J., Saima, N., Hafeez, U. R., Hassan, S., and Muhammad, A. R. (2021). Determination of total flavonoids, carotenoid and mineral content in peel, flesh and seeds of pumpkin (Cucurbita maxima). *Journal of Food Processing and Preservation 45*(1):1-8. Doi:10.1111/jfpp.15542

Basma, D. H., and Abdul-majeed, C. V. (2013). Protein-water interactions and functional properties. *American Journal of Oil Chemistry 5*(6): 53-56.

Bwade, E. K., Aliyu, B., and Kwaji, A. M. (2013). Physicochemical properties of pumpkin seed oil relevant to biodiesel production and other industrial applications. *International Journal of Engineering Business and Enterprise Application 13*(126):72-78.

Carly, S. (2024). This thanksgiving staple is banned in other countries because of 2 ingredients linked to cancer. Health. https://nypost.com/2024/11/27/health/ingredients-in-this-thanksgiving-food-arelinked-to-cancer/?utm_source

Codex Alimentarius Commission. (1999). Standard for named vegetable oils. (CXS 210-1999). Retrieved from FAO website: https://www.fao.org/fao-who codexalimentarius/sh-proxy/fr/?lnk=1&url=https% 253A%252F%252Fworkspace.fao.org%252Fsites% 252Fcodex%252FStandards%252FCXS%2B210 1999%252FCXS_210e.pdf

Cowan, S. T. (2005). Manual for the identification of medical bacteria 2nd edited by S.T Cowan and K.J Steel Cambridge. Cambridge university press.

Djeridane, A., Yousfi, M., Nadjemi, B., Boutassouna, D., Stocker, P., and Vidal, N. (2006). Antioxidant activity of some Algerian medicinal plants extracts containing phenolic compounds. *Journal of Food Chemistry* 97:654-660.

Ekundayo, S. (2024). Navigating seasonal surge: annual tomato price hike in Nigeria. The vanguard.

Eleyowo, O. O., and Amusa, O. D. (2021). Antioxidants, microbial load and heavy metal contents of some sachet tomato paste obtained in Lagos State Nigeria. *Journal of Applied Science and Environment Management 25*(4):631-636.

Elizabeth, Q. (2024). Dry them, fry them, turn them into sauce: what to cook with cheap, juicy summer tomatoes. The Guardian. https//www.theguardian.com/food/2024/dec/21/best-recipes-for-tomatoes-summer-cooking?utm_source

Folinas, D., Aidonis, D., Triantafillou, D., and Malindretos, G. (2011). Exploring the greening of the food supply chain with lean thinking techniques, 6th International Conference on Information and Communication Technologies in Agriculture, Food and Environment. *Journal of food safety and hygiene 4*(12): 19-22.

Gyawali, R., and Ibrahim, S. A. (2014). Natural products as antimicrobial agents. *Food Control 46*: 412-429.

Harvard Health Publishing (2023). Seed of the moth: pumpkin seeds. Harvard Medical School.htttps://www.health.harvard.edu./heart/seed-of-the-month-pumpkin-seeds?utm_source

ISO (1996). Animal and vegetable fats and oils Determination of acid value and acidity (ISO 660:1996). Geneva, Switzerland: ISO Central Secretariat.

Kathi, V. (2025). Ten (10) pumpkin seed benefits you might not expect. Diet and nutrition. Updated February 17, 2025, very well health.

Krishnaiah, D., Sarbatly, R., and Bono, A. (2002). Phytochemical antioxidants for health and medicine – A move towards nature. *Journal of Plant Biotechnology and Molecular Biology 1*(4): 97-104.

Lazos, E. S. (2006). Nutritional, Fatty Acid, and Oil Characteristics of Pumpkin and Melon Seeds. *Journal of Food Science 5*(1): 182-183.

Nurham, T. D. (2016). Edible oil quality Extension OKState.edu FAPC-197. https.//extension.okstate.edu.

Madigan, M. T., Martinko, J. M., Stahl, D. A., and Clark, D. P. (2012). Cell structure and function in bacteria and archaea. *Brock biology of microorganisms*, *49*.

Markovic, V. V., and Bastic, L. V. (2005). Characteristics of Pumpkin Seed Oil. Journal Amino acid and Food Chemistry 5(3): 42-44.

Medini, F., Fellah, H., Ksouri, R., and Abdelly, C. (2014). Total phenolic, flavonoid and tannin contents and antioxidant and antimicrobial activities of organic extracts of shoots of the plant Limonium delicatulum. *Journal Taibah University Science 8*:216-224. doi: 10.1016/j.jtusci.2014.01.003

Mikolajczak, N., Tanska, M., and Ogrodowska, D. (2021). Phenolic compounds in plant oils: A review of composition, analytical methods, and effect on oxidative stability. *Trends Food Science Technology* 113:110-138.

Mohammed, M. I., and Hamza, Z. U. (2008). Physiochemical properties of oil extracts from *sesamum indicum* L. Seeds growth in Jigawa state. *Nigeria. Journal of Applied sciences and Environmental Manual 12* (5): 99-101.

Nakic, S. N., Rade, D., Skevin, D., Strucelj, D., Mokrovcak, Z. and Bartolic, M. (2006). Chemical Characteristics of Oils from Naked and Husk Seeds of *Cucurbita pepo* L. *European Journal of Lipid Science and Technology 1*(8): 36-43.

Nichols, D. S., Sanderson, K. (2003). The Nomenclature, Structure, and Properties of Food Lipids. In Chemical and Functional Properties of Food Lipids (Z. E. Sikorski, and A. Kolakowska, eds.) CRC Press. Pp. 29-59.

Nkosi, C. Z., Opoku, A. R., and Terblanche, S. E. (2006). Antioxidative effects of pumpkin seed (Cucurbita pepo) protein isolate in CCl4-induced liver injury in low-protein fed rats. *Phytotherapy Research 20*(11):935-940.

Olaniyi, J. O., Akanbi, W. B., Adejumo, T. A., and Akande, O. G. (2010). Growth, fruit yield and nutritional quality of tomato varieties. *African Journal of Food Science 4*(6): 398-402.

Olunkunle, O. F., and Eesuola, E. O. (2008). Microbial population of processed tomato puree. Biosciences Biotechnology Research Asia 5:1. Available from https://www.biotech-asia.org/?p=6510

Olusanya, B. O. (2001). Effect of moisture removal on quality attributes of tomato. Project of BSC in Department of Food Technology. Ibadan, Nigeria, 57pp.

Raffaele, R., Lucia, D. L., Nadia, M., Fabiana, P., and Alessandra, A. (2020). A new type of tomato puree with high content of bioactive compounds from 100% whole fruits. *Journal of Food Science* 85(10): 3264-3272.

Rezig, L., Chouaibi, M., Msaada, K., and Hamdi, S. (2012). Chemical composition and profile characterisation of pumpkin (Cucurbita maxima) seed oil. *Industrial Crops and Products 37*(1):82-87.

Sani, I., Sule, F. A., Warra, A. A., and Bello, F. (2013). Phytochemicals and mineral elements composition of white *Sesamum indicum L.* Seed oil. *International Journal of Amino Acid Chemistry 6*(1): 28-31.

Santos, R. G., Loh, W., Bannwart, A. C., and Trevisan, O. V.

(2014). An overview of heavy oil properties and its recovery and transportation methods. *Brazilian Journal of Chemical Engineering 31*(3): 571-590. https://doi.org/10.1590/0104 6632.20140313s00001853

Singh, D., and Sharma, R. R. (2007). Postharvest disease of fruit and vegetables and their management. In: Prasad, D. (ed). Sustainable pest management. Daya Publishing House, New Delhi, India. Pp 183-189.

Tomato puree market (2024). Allied market research, page 190, tomato puree market size, share, competitive landscape and trend analysis report, by nature, by packaging, by application, by distribution channel: global opportunity analysis and industry forecast, 2023-2032. https://www.alliedmarketresearch.com/tomato-puree-market-A11031?utm_source

Tran, D. X., Gu, G., Truong, N. M., Tran, N. Q., and Tran, D. K. (2018). An overview of chemical profiles, antioxidant and antimicrobial activities of commercial vegetable edible oils marketed in Japan. *Foods 7*(2):21.

Tsaknis, J., Lalas, S., and Lazos, E. S. (2007). Characterization of Crude and Purified Pumpkin Seed Oil. *Journal for oils and purified essential oils 4*(8): 6-72.

Wazed, M. A., Yasmin, S., Basak, P., Hossain, A., Rahman, M. M., Hasan, M. R., Khar, M. M., and Khatun, M. N. (2023). Evaluation of Physicochemical Parameter of Edible Oils at Room Temperature and after Heating at High Temperature. *Food Research 7*(4):91-100.

Wong, M. L., Timms, R. E., and Goh, E. M. (2008). Colorimetric Determination of Total Tocopherols in Palm Oil, Olein and Stearin. *Journal of Amino Acid and Food Chemistry 6*(5): 258-261.

Xianli, W., Liangli, Y., and Pamela, R. P. (2021). Are processed tomato product as nutritious as fresh tomatoes? Scoping review on the effects of industrial processing on nutrients and bioactive compounds in tomatoes. *Advances in nutrition 13*(1):138-151. Doi:10.1093/advances/nmab109

Xue, C., Le,i Q., Bujiang, W., Zhijun, Z., Han, L., Yeni, Z., and Jinfu, L. (2019). Synergistic hypoglycemic effects of pumpkin polysaccharides and puerarin on type ii diabetes mellitus mice. *Molecule 24*(5):955. Doi:10.3390/molecules24050955.

Yoshida, H., Tomiyama, Y., Hirakawa, Y., and Mizushina, Y. (2006). Microwave Roasting Effects on the Oxidative Stability of Oils and Molecular Species of Triacylglycerols in the Kernels of Pumpkin (*Cucurbita spp*.) Seeds. *Journal of Food Composition Analysis 1*(9): 30-39.

Younis, Y. M. H., Ghirmay, S., and AlShihry, S. S. (2000). African *Cucurbita pepo* L.: Properties of Seed and Variability in Fatty Acid Composition of Seed Oil. *Journal of Phytochemicals 5* (4): 71-75.

Zahir, E, Saeed, R., Hameed, M. A., and Yousuf, A. (2017). Study of physicochemical properties of edible oil and evaluation of frying oil quality by Fourier Spectroscopy. Transform-Infrared (FT-IR). *Arabian Journal of Chemistry 10*(2): S3870-S3876. https://doi.org/10.1016/ j.arabjc.2014.05.025