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Research Article
The Effect of Lemongrass (*Cymbopogon citratus*) Essential Oil on Shelf-Life of Yoghurt

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Abstract

Background and Objective: Microbial contaminations in the food chain remain one of the topmost causes of dairy food spoilages which eventually result in wastage, alarming food insecurities that threaten global peace in addition to a considerable economical loss. Preservative chemicals from synthetic routes are often employed for controlling microbial food spoilage and extending products' shelf-life. Whereas these chemical products used have a lot of side effects on human health. This study aimed to investigate the bio-preservative potential of lemongrass essential oil (EO) on yoghurt. **Materials and Methods:** Physico-chemical, sensory and microbiological characteristics were studied. Lemongrass EO was extracted via steam distillation. **Results:** Results of the total bacterial count (TBC) for yoghurt ranged from $117.33\pm2.31\times10^6$-$294.67\pm2.31\times10^6$, total lactobacillus count (LBC) ranged from $113.33\pm5.77\times10^6$-$240\pm20.00\times10^6$ while at 1.0 and 2.0 μL mL^{-1} EO prevented the growth of fungi for up to 7 days. Results show that the sensory acceptability of yoghurt supplemented with lemongrass EO was higher than that of the control yoghurt prepared without EO. The yoghurt sample treated with 2 μL mL^{-1} was found to be mostly acceptable ($p<0.05$). **Conclusion:** The present findings suggest that the addition of lemongrass essential oil could improve the shelf life of yoghurt for up to 7 days at room temperature.

Key words: Lemongrass, essential oil, yoghurt, bio-preservation, shelf-life, lactobacillus, fungi

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

One of the most dailies discussed global public health issues is food safety globally[1]. Food is indispensable for any healthy human being global. Numerous food products are liable and susceptible to being easily destroyed by nature, thus necessitating adequate protection from spoilages during various stages of preparations, storages and distributions to achieve a desirable shelf-life[2]. Increasing food shelf-life will not only have significant economic impacts to reduce losses associated with spoilages but also allow the products to be transported to far distant and reach the new markets unspoiled.

Food preservation suffers a progressive fight against microorganisms that spoil the food and make them unsafe. The intake of such food can cause serious deadly diseases. The discharge of such food into the receiving bodies pollute the surrounding, they stink and pose an unbearable odour which makes the environment to be unsafe for the populace. In fact, through this means people even consume them indirectly via inhalation and this finally causes different health challenges. Until now, chemical preservatives, antibiotics or the application of more drastic physical treatments such as high temperatures or refrigeration are some of the approaches used in the preservation of food. Nevertheless, these approaches have many disadvantages including reduction or impairment and/or probiotic strains, teratogenic, residual toxicities, cardiovascular and carcinogenic diseases[3].

Dairy loss is one of the major problems of the dairy industry in developing countries, especially in Africa[4]. Losses that occur at the farm are attributed to unsanitary handling of milk, poor milking procedure and spoilages associated with lack or inefficient cooling facilities. Pasteurization has been used as a public health technique for eliminating, reducing and/or slowing the activities of microorganisms that causes spoilage in milk. However, some microorganisms such as *Bacillus* and *Streptococcus* species are likely to survive pasteurization due to their ability to form heat-resistant endospores[5]. On the other hand, non-endospore-forming bacteria, including *Listeria monocytogenes*, *Mycobacterium paratuberculosis* and *Escherichia coli* serotype O157:H7 can also survive boiling at 63°C for 15 min. This makes microbes the main cause of milk spoilage[6].

Inhibiting the growths and activities of microorganisms are regarded as one of the major drives for using chemical preservatives[7]. Owing to the lack of household refrigeration facilities and poor electricity supply in many Nigeria rural areas and some parts of West Africa, several attempts have been made for improving the shelf-life of yoghurt. Common examples are the usage of antibiotics including natamycin, chemical preservatives e.g. sodium benzoate, propionic acid, sorbic acid, etc for preserving yoghurt. However, the alarming increase in demands for safe food, with fewer or nope chemical additives, has resulted in keen interest among the researchers to replace these compounds with natural products, which pose no injury to the host and the environment[7] since chemical products used for conserving food have a lot of side-effects on human health. Carcinogenic, teratogenic, allergic and high toxic effects are the most important problems of this chemical additives[8]. Essential oils often possess antimicrobial properties[9,10], They are proven to have antimycotic, antioxidant, antiviral, insecticidal and antiparasitic properties as well as antibacterial actions. Therefore, using natural antimicrobials to control spoilage and pathogenic microorganisms is gaining a renewed interest[11]. Therefore, this present study aims at investigating the effect of lemongrass essential oil (EO) on the shelf-life of yoghurt.

MATERIALS AND METHODS

Study area: The study was conducted in the Laboratories at the Department of Biochemistry and Department of Microbiology, Bayero University Kano, Nigeria from February-September, 2019.

Essential oil extraction: *Cymbopogon citratus* samples were collected from Rimi market Kano, Nigeria. The method of EO extraction by Fitriady *et al.*[12], Kamaliroosta *et al.*[13] and Aziza and Okiy[14], was adopted in this study. The samples were ground, homogenized and made into a fine powder. About 500 g of the powdered sample was placed in the clevenger apparatus. About 1 L distilled water was added to the flask and heated to boiling point. A beaker was used to collect the extract as the distillate. Then the extract was further distilled to remove excess water and get a more concentration of the oil extract. The percentage yield of the EO was calculated using:

$$\text{Yield of essential oil} = \frac{\text{Amount of essential oil (in g) obtained}}{\text{Amount of raw materials (in g) use}} \times 100$$

Yoghurt preparation: The yoghurt sample was prepared at the Sensory Evaluation Laboratory of the Department of Biochemistry Bayero University, Kano, Nigeria. About 12 L cow's milk was heated up to 85°C for 20 min and then cooled to 44±1°C for the inoculation of starters (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) added in the milk (Manufacturers Standard)[15].

Physicochemical analysis: Physico-chemical analyses were carried out according to the method of Omola *et al.*[16].

Measurement of pH: The pH of yoghurt samples was measured using a lab tech pH meter with a glass electrode.

Titratable acidity: The titratable acidity was measured by titrating 15 mL of the yoghurt with 0.1 M sodium hydroxide until the substance reached a pH value of 8.2, corresponding to the endpoint of the phenolphthalein.

Readings were done with a pH meter (JENWAY 3505). When this value was reached, the spent NaOH volume was recorded and the acid percentage of the substance was calculated using the formula[17]:

$$\text{Titratable acidity} = \frac{\text{Titre value} \times \text{M} \times 90 \times 100}{\text{Volume of sample} \times 10000}$$

where, M is Molar concentration of NaOH.

Ash content determination: The ash content was determined by the direct heating method as described by Bibiana *et al.*[17]. About 2 g of the yoghurt samples were weighed in dried glass crucibles separately. The samples were then incinerated to ash in a muffle furnace for 3 hrs at 550°C. The crucibles were then removed, cooled in a desiccator and the weight of the ash was determined. The percentage ash content was calculated by the following Eq.:

$$\text{Ash (\%)} = \frac{Z - X}{Y - X} \times 100$$

Where:

X = Weight of empty crucible
Y = Weight of crucible+sample
Z = Weight of crucible+ash

Moisture content determination: The percentage of moisture content was determined by the oven method as described by Bibiana *et al.*[17]. About 2 g of yoghurt sample was dried in the oven for 24 hrs at 100°C. The percentage moisture content was calculated by the following Eq.:

$$\text{Moisture (\%)} = \frac{W1 - W2}{W1} \times 100$$

Where:

W1 = Initial weight of sample
W2 = Weight of the dried sample

Total solids: The weight of the residue obtained from moisture content analysis was expressed as percentage of total solids using the formula below:

$$\text{Total solids (\%)} = (100\text{-\% moisture})$$

Viscosity: Viscosity was measured using a viscometer model DV–E viscometer using a glass tube and a normalized ball equipped with a chronometer at 20°C. Viscosity was as expressed as centipoise.

Microbial growth and sensory test: Determination of microbial growth and sensory evaluation of the yoghurt sample was done every 48 hrs after the first preservation of yoghurt samples with Lemongrass essential oil and at the expiration of shelf life of the yoghurt. The yoghurt sample was inoculated with Lemongrass EO at 0.5, 1and 2 µL mL^{-1}. microbial growth was determined using the colony count method.

Colony count: The total colony count was carried out using the pour plate method as described by De *et al.*[18]. 1mL Yoghurt sample was aseptically introduced into 9 mL of peptone water solution. Serial dilutions for each sample were made up to 10^{-6}. Discrete colonies that appeared on the plates after appropriate inoculation and incubation were counted using a digital colony counter. The total viable count (TVC), lactobacillus count (LBC) and fungal count (FC) were obtained on nutrient agar, mann rogosa sharpe (MRS) agar and Sabouraud dextrose agar, respectively[19]. The numbers of colonies counted were multiplied by the reciprocal of the dilution factor plated and divided by the volume of inoculums used to obtain the Colony-Forming Unit per millilitre (CFU mL^{-1}) of each sample. This is expressed as:

$$\text{CFU mL}^{-1} = \frac{\text{Number of colony counted} \times \text{Reciprocal of dilution factor}}{\text{Volume inoculated}}$$

Sensory evaluation: The sensory evaluation analysis was carried out using the questionnaire adopted by Soukoulis *et al.*[15]. A group of 8 panellists was chosen from students and teaching staff of the Biochemistry Department of Bayero University Kano to evaluate the yoghurt samples. The bio-preserved yoghurt was then served randomly in coded plates plus a control sample. Each of the Panelists was given the samples in a plastic jar (100 mL) to score from the lowest (1) to the highest (9) and make a critical evaluation of colour, aroma, texture, taste and general acceptability of the bio-preserved yoghurt on the 1st, 3rd, 5th and 7th days of

storage by a 9-point hedonic scales (template use included as Appendix I) which was adapted from Yangilar and Yildiz[20]. Each of the samples underwent the same test conditions and panellists were allowed to use a separate clean plate for the samples. The organoleptic scores generated for each attribute were analyzed statistically using Analysis of Variance (ANOVA).

Appendix I

Sensory scorecard for
Sensory evaluation of bio-preserved yogurt

Name of respondent (Optional):

ID number: **Date:**

Kindly evaluate the given samples for attributes like appearance, taste, texture, aroma and general acceptability using the following 9-point hedonic scale and enter the scores in the space provided in the table below

Hedonic rating score			
Like extremely			9
Like very much			8
Like moderately			7
Like slightly			6
Neither like nor dislike			5
Dislike slightly			4
Dislike moderately			3
Dislike very much			2
Dislike extremely			1
Control	L_{11}	L_{12}	L_{13}
Appearance			
Taste			
Texture			
Aroma			
Acceptability			

Remarks (if any):

RESULTS AND DISCUSSION

Percentage yield and mean volume of EO obtained from LG:

Table 1 shows the mean volume of EO yield from lemongrass. From 481.25±25.88 g of plant material used, a total of 3.16±0.17 mL (0.66%) of EO was obtained. The obtained oil was found to be pale yellow, strong with pungent lemon scent and cooling taste. The extraction yield was calculated considering the volume of the obtained EOs and the mass (g) of dried material processed. Further investigation revealed that the essential oil was insoluble in water, miscible in alcohol and oil. The percentage yield (0.66%) obtained was similar to that of Boukhatem *et al.*[21], who reported 0.6% while Suryawanshi *et al.*[22] reported a percentage yield of 0.70%. The odour of the essential oils has been observed to be a significant diagnostic future since it has its unique odour, thereby, it is considered as a diagnostic tool for the plant(s) that contains such oils[23].

Table 2 shows the pH of the Yoghurt sample containing different concentrations of Lemongrass essential oil which were analyzed after 1, 3, 5 and 7 days of storage. The pH value of the samples varied between 4.64±0.01 to 3.93±0.15. The decrease in pH value was ascribed to the breaking down of lactose into lactic acid[24]. The pH values recorded in the samples treated with a higher concentration of lemongrass essential oil throughout the storage period were stable, thus supporting the previous finding by Ghalem and Zouaoui[24] who reported the pH in samples of yoghurt fortified with essential oil to be stable during the storage periods, whereas, a significant decreased was obtained for the control sample. Ghalem and Zouaoui[24] reported pH values ranging from 4.08-4.66 for yoghurt samples studied with *Chamaemelum* species extracts and for Lavandula species oils, pH value of 4.52-4.61 was reported. Interestingly, we observed no significant change in pH value in the first 3 days, while between the third and 7th day of storage, pH value decreased markedly.

Table 1: Mean volume and yield of LGEO obtained

Parameters	Values
Mean weight of plant material (g)	481.25±25.88
Mean volume of essential oil (mL)	3.16±0.17
Yield of essential oil (%)	0.66

Table 2: pH value of yoghurt samples treated with lemongrass EO at room temperature for 7 days

Days	-ve control	+ve control	L_1	L_2	L_3
1	4.64±0.01^a	4.64±0.01^a	4.64±0.01^a	4.64±0.01^a	4.64±0.01^a
3	4.25±0.02^a	4.45±0.00^c	4.25±0.0^a	4.33±0.02^b	4.48±0.02^c
5	3.98±0.02^a	4.06±0.01^a	4.06±0.03^a	3.97±0.01^a	4.15±0.02^b
7	3.65±0.01^a	3.91±0.02^c	3.71±0.0^b	3.85±0.02^a	4.07±0.01^d

-ve control: Without preservative, +ve control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 µL mL^{-1}, mean values in the same row with different superscript indicates significant difference ($p<0.005$)

According to Mutlag and Hassan[25], acidity is considered one of the significant factors affecting the shelf life and acceptability of yoghurt. Titratable acidity of yoghurt sample of yoghurt treated with essential oil (1.0 and 2.0 µL mL^{-1}) and artificial preservative significantly increased from 68.8±1.39-86.4±2.40 over the storage period (Table 3). The values of titratable acidity (%) and pH values gradually increased and decreased, respectively during refrigerated storage of all samples of yoghurt. This may be due to the fermentation of lactose, which produces lactic and acetic acid during the fermentation and storage period. These results are in agreement with the findings of Falade *et al.*[26] and Dzigbordi *et al.*[27]. The decrease in pH of yoghurt samples could be a result of the breakdown of lactose into lactic acid. The lactic acid produced during the fermentation period is known to be responsible for the characteristic flavour and aroma of yoghurt and this helps to maintain the quality of yoghurt during storage and packaging[28].

The ash contents (Table 4) of yoghurt treated with a high concentration of essential oil (2.0 µL mL^{-1}) stored at room temperature slightly decreased from 0.79±0.01-0.73±0.01 over the storage period.

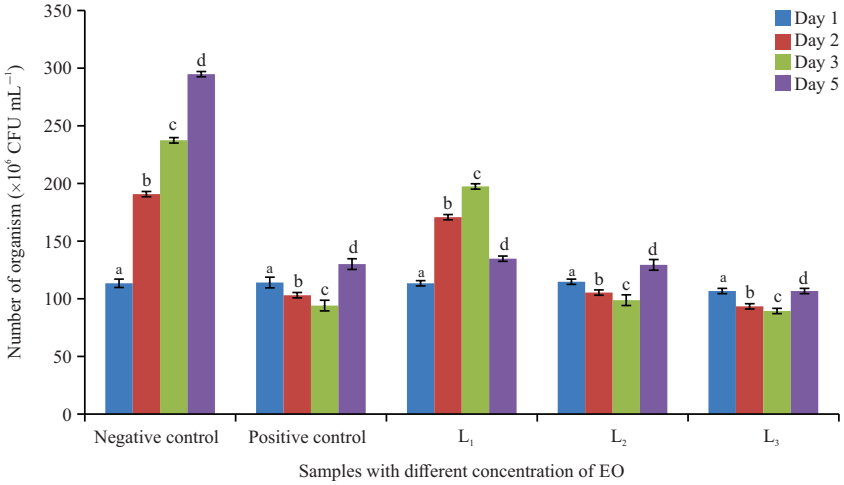

Fig. 1: Total bacterial count (TBC) of yoghurt sample treated with different concentrations of essential oils
Negative control: Without preservative, positive control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 µL mL^{-1}

Table 3: Titratable acidity of yoghurt sample treated with lemongrass EO at room temperature for 7 days

Days	-ve control	+ve control	L_1	L_2	L_3
1	68.8±1.39^a	67.2±2.4^b	68.8±1.39^a	68.0±1.39^a	65.6±3.67^c
3	76.8±2.4^a	68.8±1.39^c	73.6±1.39^b	70.6±1.21^b	68.8±1.39^c
5	81.6±2.4^a	71.3±1.21^c	76.8±2.4^b	72.8±1.39^c	70.6±1.21^d
7	86.4±2.4^a	72.8±1.39^c	81.6±2.4^b	73.6±1.39^c	70.9±1.21^d

-ve control: Without preservative, +ve control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 µL mL^{-1}, mean values in the same row with different superscript indicates significant difference ($p<0.005$)

Table 4: Ash content of yoghurt sample treated with lemongrass EO at room temperature for 7 days

Days	-ve control	+ve control	L_1	L_2	L_3
1	0.73±0.01^a	0.76±0.01^b	0.74±0.01^a	0.74±0.01^a	0.79±0.01^c
3	0.69±0.01^a	0.74±0.01^b	0.70±0.01^a	0.71±0.01^a	0.76±0.01^c
5	0.64±0.01^a	0.70±0.01^c	0.68±0.01^b	0.71±0.01^c	0.73±0.01^d
7	0.61±0.01^a	0.70±0.01^b	0.64±0.01^a	0.68±0.01^b	0.73±0.01^c

-ve control: Without preservative, +ve control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 µL mL^{-1}, mean values in the same row with different superscript indicates significant difference ($p<0.005$)

Table 5: Moisture content of yoghurt sample treated with lemongrass EO at room temperature for 7 days

Days	-ve control	+ve control	L_1	L_2	L_3
1	87.67±0.02^a	87.64±0.02^a	87.66±0.01^a	87.65±0.01^a	87.63±0.01^a
3	88.02±0.01^a	87.65±0.01^b	88.06±0.03^a	87.7±0.03^b	87.62±0.01^b
5	89.34±0.02^a	87.7±0.01^c	88.23±0.02^b	88.1±0.02^b	87.87±0.16^c
7	89.73±0.03^a	87.96±0.02^c	88.59±0.09^b	88.35±0.02^b	87.87±0.01^c

-ve control: Without preservative, +ve control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 µL mL^{-1}, mean values in the same row with different superscript indicates significant difference ($p<0.005$)

Table 6: Total solid content of yoghurt sample treated with lemongrass EO at room temperature for 7 days

Days	-ve control	+ve control	L_1	L_2	L_3
1	12.33±0.02^a	12.36±0.01^a	12.34±0.01^a	12.35±0.01^a	12.37±0.01^a
3	11.98±0.01^a	12.35±0.01^b	11.94±0.03^a	12.3±0.03^b	12.38±0.01^b
5	10.66±0.02^a	12.3±0.01^c	11.77±0.02^b	11.9±0.02^b	12.13±0.16^c
7	10.27±0.03^a	12.04±0.02^c	11.41±0.09^b	11.65±0.02^b	12.13±0.01^c

-ve control: Without preservative, +ve control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 µL mL^{-1}, mean values in the same row with different superscript indicates significant difference ($p<0.005$)

The moisture content (Table 5) of the yoghurt samples ranges from 87.67±0.02-89.73±0.03 during storage at room temperature. Moisture content remains stable with the addition of a high concentration of EO.

The total solid contents (Table 6) of yoghurt treated with artificial preservatives ranged from 12.36±0.01-12.04±0.02 over the storage period. While total solid content decreased in yoghurts samples without preservatives and samples with a low concentration of EO.

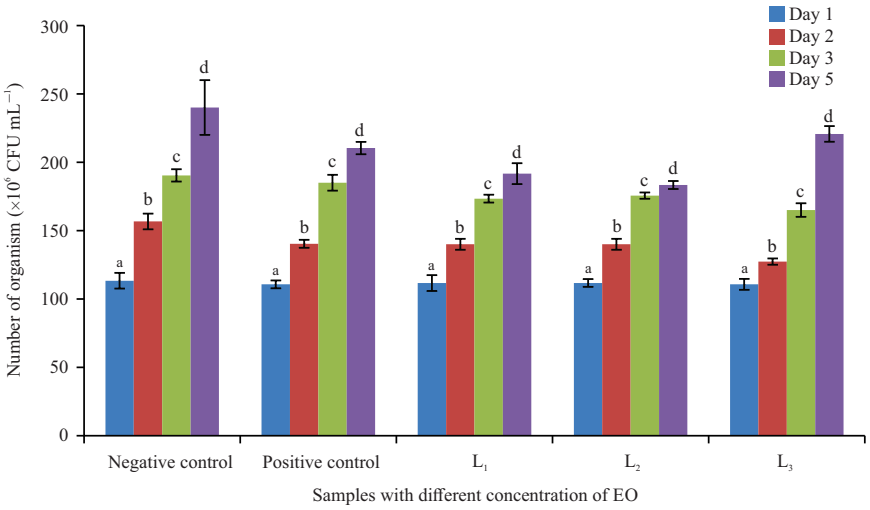

Fig. 2: Total lactic acid bacteria (LBC) Count of yoghurt samples treated with different concentrations of essential oils
Negative control: Without preservative, Positive control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 μL mL^{-1}

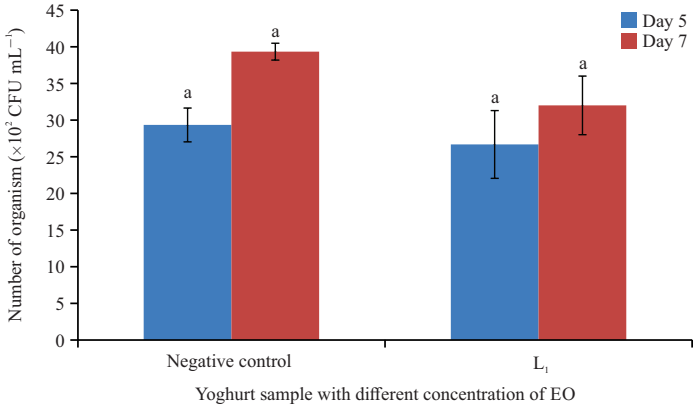

Fig. 3: Total fungal count (TFC) of yoghurt sample treated with different concentrations of essential oils
Negative control: Without preservative and L_1 = 0.5 μL mL^{-1}

The viscosity of yoghurt (Table 7) treated with a high concentration of essential oil (2.0 μL mL^{-1}) stored at room temperature remains stable over the storage period.

Figure 1 depicts the result of the total bacterial count on produced yoghurt samples treated with different concentrations of EO extracted from lemongrass. The TBC tends to decrease with an increase in the concentration of EO. High bacteria counts could be expected as a result of the addition of starter culture: Mainly lactic acid bacteria. The standard aerobic bacterial count is 10^6-10^7 CFU mL^{-1}[29]. A high count indicates post pasteurization contaminations owing to hygienic inadequacy measures during productions. This is a common phenomenon in foods, particularly dairy products. Total bacteria count is frequently used as evidence of safety, good hygiene, sanitary qualities and food utilities. This majorly reflects the conditions in which the products are manufactured including raw material and ingredient contaminations, processing efficiency and the sanitary of equipment condition plus utensils at the processing plants[4].

The total count of lactic acid bacteria (LBC) increases with an increase in the concentration of essential oil (Fig. 2). It has been reported that the addition of some aromatic and essential oils to yoghurt and labneh during its manufacture had a stimulatory effect on lactic acid bacteria by enhancing their growth and acid production[30]. LAB enumerating indicates the levels of added starter culture and its development during the storage and shelf-life[29].

There was no fungal growth observed across each concentration of EO used from day 1-3 (Fig. 3). However, fungal growth was observed on day 5 and 7 at the control and 0.5 μL mL^{-1} with TFC ranged from 30.67±2.31-38.67±2.31 in control and 22.67±2.31-30.67±2.31 CFU mL^{-1} using 0.5 μL mL^{-1} of EO, respectively. The quality and the shelf life of yoghurt was evaluated with fungal counts, fungi were

Table 7: Viscosity of yoghurt sample treated with lemongrass EO at room temperature for 7 days

Days	-ve control	+ve control	L_1	L_2	L_3
1	61.23±0.87^a	62.17±0.29^b	61.23±0.87^a	61.57±0.51^a	62.83±0.76^b
3	57.8±0.76^a	61.00±0.87^b	58.5±0.29^a	59.93±0.5^b	61.33±0.28^c
5	55.17±0.36^a	61.00±0.66^c	55.93±0.62^a	58.27±0.28^b	61.33±0.28^c
7	53.73±0.75^a	59.93±0.75^c	54.17±0.87^a	55.33±0.87^b	61.00±0.36^c

-ve control: Without preservative, +ve control: With artificial preservative, L_1: 0.5, L_2: 1.0 and L_3: 2.0 μL mL^{-1}, mean values in the same row with different superscript indicates significant difference ($p<0.005$)

Table 8: Sensory scores of yoghurt samples treated with lemongrass essential oil at room temperature for 7 days

	EO Dosage (μL mL^{-1})			
	Control	0.5	1.0	2.0
Day 1				
Appearance	8.63±0.52^a	8.63±0.52^a	8.75±0.46^a	8.75±0.46^a
Taste	7.63±0.52^a	7.63±0.52^a	7.75±0.46^a	7.88±0.35^a
Texture	7.88±0.35^a	8.13±0.35^a	8.25±0.46^a	8.38±0.52^a
Aroma	7.75±0.46^a	7.88±0.35^a	8.13±0.35^a	8.38±0.52^b
Acceptability	8.38±0.52^a	8.5±0.53^a	8.75±0.46^a	8.75±0.46^a
Day 3				
Appearance	4.50±0.53^a	4.63±0.52^{ac}	5.25±0.46^{bc}	5.75±0.46^{bd}
Taste	2.88±0.64^a	3.00±0.53^{ac}	3.38±0.52^a	3.88±0.35^{bd}
Texture	3.50±0.53^a	3.63±0.52^{ac}	4.38±0.92^a	4.88±0.83^{ad}
Aroma	3.78±0.52^a	3.50±0.53^{ac}	4.13±0.35^{bc}	4.75±0.46^{bd}
Acceptability	3.13±0.64^a	3.38±0.52^a	3.88±0.64^a	4.13±0.64^b
Day 5				
Appearance	3.50±0.53^a	3.63±0.52^{ac}	4.13±0.35^a	4.75±0.46^{bd}
Taste	2.25±0.71^a	2.38±0.52^{ac}	3.13±0.64^b	3.63±0.52^{bd}
Texture	3.13±0.83^a	3.38±0.74^{ac}	4.13±0.64^a	4.50±0.76^{bd}
Aroma	2.63±0.51^a	2.75±0.46^{ac}	3.38±0.52^b	3.75±0.46^{bd}
Acceptability	2.50±0.53^a	2.88±0.83^{ac}	3.38±0.52^a	3.88±0.83^{bd}
Day 7				
Appearance	3.00±0.76^a	3.13±0.64^{ac}	3.75±0.71^a	4.25±0.46^{bd}
Taste	1.88±0.64^a	2.00±0.53^{ac}	2.88±0.35^{bd}	3.25±0.46^{bd}
Texture	2.50±0.53^a	2.88±0.35^{ac}	3.5±0.53^{bc}	4.00±0.76^{bd}
Aroma	2.13±0.64^a	2.25±0.71^a	3.00±0.76^a	3.63±0.52^b
Acceptability	1.63±0.52^a	1.75±0.46^{ac}	2.38±0.52^{bc}	2.63±0.53^{bd}

*Results are a mean score of 8 judges, *Values are described as Mean±SD, *Mean values followed by different letters in the same row are significantly different ($p<0.05$)

not detected in yoghurt sample containing a high concentration of lemongrass EO (1 and 2 μL mL^{-1}) throughout the storage period, while in yoghurt sample containing lower concentration and sample without treatment fungi were detected at day 5 and 7 of storage. These results are in agreement with both Abd-El Fattah *et al.*[31], who reported that 0.1% of the EO extract of lemongrass was effective in inhibition of both mould growth and mycotoxin production for 30 days at 5°C.

Table 8 shows the results of the total mean score of sensory characteristics for control and yoghurt treated with different concentrations (0.5, 1.0 and 2.0 μL mL^{-1}) of lemongrass essential oil for days 1, 3, 5 and 7. The LGEO pretreated yoghurt samples established a high sensory score from panellists than the yoghurt samples without treatment. No significant differences ($p<0.05$) for all sensory characteristics were observed on day 1 except for aroma. The addition of LGEO in yoghurt had a significant ($p<0.05$) impact on taste and aroma but insignificant ($p<0.05$) on texture and appearance characteristics. The yoghurt sample treated with 2.0 μL mL^{-1} EO received a better score for taste and aroma. On the contrary, a lower concentration of essential oil showed a low score of sensory characteristics in all samples. Nevertheless, the concentration of LGEO showed positive influences on the general acceptability and satisfactoriness of the yoghurt samples. This observation showed similarity with the results reported by other authors[24,30,32].

The trend of using EOs as natural antimicrobial agents is becoming an attractive approach in the field of food preservation. The regulation and new method of application of natural antimicrobials agents are important factors that should be addressed. Optimization of application methods and regulations will enhance consumer confidence. For the practical use of this oil, further research is needed on safety issues for human health and acceptability by consumers. Also, identifying the main components of the essential oil and testing their safety to uncover their full potential.

CONCLUSION

Lemongrass EO enhances the flavour and taste of yoghurt and is recorded as best in overall acceptability. It was seen in this research Lemongrass EO affects the total bacterial viability, total lactic acid bacteria viability and fungal growth in yoghurt. Therefore, the addition of Lemongrass EO in the process of yoghurt production serves as an alternative to conventional chemical preservatives in the preservation of yoghurt.

SIGNIFICANCE STATEMENT

This study discovered the potential of lemongrass essential oil as a natural preservative that increases the shelf life of yoghurt. This study will help researchers explore the preservative potentials of essential oils from the natural product as an alternative to synthetic preservatives.

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