Valorization of Bay Leaf Essential Oil as a Bioplasticizer and Antibacterial Agent in Polybutylene Adipate-co Terephthalate Biofilms for Food Packaging Applications

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Although the high flexibility of PBAT (polybutylene adipate-co-terephthalate) makes it ideal for food packaging, its poor antibacterial properties restrict its use in the food industry and shorten the shelf life of food products. In this work, PBAT polymer film was modified with bay leaf essential oil to improve its antibacterial properties. Gas chromatography-mass spectrometric analysis showed 38 chemical components in bay leaf. The main absorbances were the strong C=O stretching of the ester group (1720 to 1730 cm^{-1}) and the aliphatic C–H stretching (2950 and 2850 cm^{-1}). An increase in the amount of essential oil resulted in a decrease in the melting temperature of the PBAT, confirming a plasticizing effect. No antibacterial activity was observed in the PBAT films containing 5 wt% or 10 wt% bay leaf oil against either gram-positive or gram-negative bacteria. However, PBAT films containing 15 wt% and 20 wt% bay leaf oil exhibited zone diameters of 8 and 12 mm, respectively, against the *E. coli* strain. PBAT films with enhanced plasticizing and antibacterial properties, resulting from the addition of 20 wt% bay leaf oil, could be of great interest to the food packaging and biomedical industries.

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Keywords: Bay leaf; Essential oil; Biofilm; Antibacterial activity; Bioplasticizer

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INTRODUCTION

Growing world population, urbanization and globalization have increased the challenges of global food security and food storage stability. Synthetic plastics derived from petrochemicals, such as polypropylene, polyethylene, and polystyrene, are widely utilized as food packaging materials due to their cost-effectiveness, mechanical strength, and barrier properties (Marsh and Bugusu 2007; Shaikh *et al*. 2021; Kumari *et al*. 2024). However, these polymers have resulted in significant environmental concerns because they do not degrade in nature (Kumari *et al*. 2024). Their price is also fluctuating due to changing oil supply. The generation of plastic waste and the subsequent uncontrolled

plastic pollution is one of the most important environmental problems that governments and organizations must face today. Declining petroleum resources, increased awareness of sustainability, and stricter regulations on solid waste management will encourage the replacement of synthetic plastic packaging materials and the use of more sustainable alternatives and solutions (González-López *et al*. 2023). The packaging industry is looking for environmentally friendly alternatives to synthetic plastics, with a particular focus on biodegradable plastic. This is due to the disadvantages of synthetic plastics such as limited natural degradation, chemical additives such as bisphenol A and phthalates. As a result, plastic waste contributes to the world economy through direct (plastic pollution, marine ecosystem degradation, and clean-up costs) and indirect (public health problems) costs.

The primary function of packaging is to preserve, distribute, and commercialize food products. Consequently, there is a growing interest on research for biodegradable food packaging alternatives. Among the biodegradable polymers, polylactic acid (PLA) and polyhydroxyalkanoates (PHAs), PBAT (polybutylene adipate terephthalate), are the most known polymers (Mishra *et al*. 2024). Although the antibacterial properties of the PLA and PHA polymers have been investigated in previous studies (Swetha *et al*. 2023; Mishra *et al*. 2024; Reshma *et al*. 2024; Lee and Salleh 2025), the number of studies on the PBAT polymer is relatively small.

PBAT is a biodegradable and compostable form of plastic which is garnering increasing attention as a solution to the issue of plastic waste in the environment. It is manufactured using renewable resources, which are 1,4-butanediol, adipic acid, and terephthalic acid. These are prepared from such plant-based materials as corn starch and sugarcane, and they can break down naturally in the environment (Ghasemlou *et al*. 2024). The thermal and mechanical properties of PBAT exhibit behavior similar to certain types of polyethylene, such as low-density polyethylene (LDPE) Hemsri *et al*. 2020). Moreover, PBAT has greater flexibility than other biodegradable polyesters, such as PLA and PHB (Hemsri *et al*. 2020). In the field of biodegradable polymers, PBAT has recently garnered significant attention because of its inherent compostability and biocompatibility. With the help of natural enzymes, PBAT can be completely degraded in compost or soil within a few weeks (Gioia *et al*. 2021). PBAT is a highly valued biodegradable polymer in the food packaging industry due to its excellent physical properties such as ease of processing, high flexibility (comparable to low density polyethylene (LDPE)) for the extrusion of blown films in the packaging industry, ease of processing, toughness, and safe food contact (Roy *et al*. 2024).

Use of innovative and sustainable packaging materials such as bioplastics is necessary to maintain food quality and safety, reduce food losses, and minimize the environmental carbon footprint. Recently, there has been an increasing interest in natural and sustainable sources to use in place of synthetic antibacterial chemicals, especially in the packaging industry using polymeric thin films (Roy *et al*. 2024). Due to the increasing human population, the food industry is growing rapidly, and it is very important to increase the antibacterial properties of packaging materials to extend the shelf life of the products. The most important disadvantage of packaging films made of biodegradable polymers obtained from natural sources is that they are degraded too fast by bacteria, due to their plant-based origin (Verma *et al*. 2024). This situation accelerates the moulding of foods in the packaging industry of biodegradable polymers and shortens the shelf life of the products. In order to minimize this, chemicals that provide antibacterial properties are added to the polymers. Antibacterial metals such as silver, zinc, and copper have been used for centuries in biodegradable polymers for the packaging industry. However,

antimicrobial metallic nanoparticles are heavily constrained by their toxicity, environmental hazards, and the risk of promoting new resistances, meaning that their use is limited. Metallic nanoparticles are able to penetrate biological barriers (such as the blood-brain barrier) and enter human cells easily due to their ultra-small size. For this reason, substitution of a different kind of antimicrobial agent, *e.g.* essential oils derived from plants with antibacterial properties to biopolymers, is becoming increasingly important (Ayrilmis *et al*. 2021). Biofilms that contain natural active agents offer certain advantages over synthetic biofilms. These include lower concentrations of antibacterial substances and slower diffusion rates (Fydrych *et al*. 2025). Therefore, the use of essential oils with antibacterial properties obtained from renewable plant sources for industrial applications is becoming increasingly attractive due to their sustainability and harmlessness to human health (Threepopnatkul *et al*. 2022; Dutta and Sit 2023).

Previous studies have reported that biofilms containing antibacterials have been shown to affect the growth of pathogenic microorganisms (Ayrilmis *et al*. 2021; Threepopnatkul *et al*. 2022; Dutta and Sit 2023; Raikwar *et al*. 2024; Fydrych *et al*. 2025). Despite the existence of these synthetic preservatives, there is growing consumer interest in natural antibacterial agents due to their non-toxicity in most cases. Current knowledge of essential oils covers approximately 3,000 different plant species, of which only 300 are of commercial importance in the flavor and fragrance market (Fydrych *et al*. 2025). The pharmaceutical, cosmeceutical, and food industries have shown considerable interest in the multifunctional properties of essential oils (Sharmeen *et al*. 2021; Dutta and Sit 2023). For example, food-grade essential oils with spicy and herbal flavors are highly valued in the meat, sauce, bakery, and beverage industries for their antibacterial and antioxidant properties (Varghese *et al*. 2020). Recently, there has been an increasing trend in the use of essential oils extracted from various spices having antibacterial and antioxidant compounds such as flavonoids and phenolics as potential additives for packaging films (Threepopnatkul *et al*. 2022; Luna *et al*. 2024; Ke *et al*. 2024). Biologically active compounds with antioxidant, antibrowning, and antibacterial properties are found in abundance in natural extracts. Thus, food quality can be retained, and the shelf life of the packaged product can be enhanced in an environmentally friendly way if active agents are incorporated into biopolymeric packaging films.

Among spices, the essential oil extracted from leaves of bay laurel or sweet bay is in industrial demand because of its aromatic and spicy flavor, as well as its recognized antioxidant and antibacterial properties, in Mediterranean and East Asian regions (Rincón *et al*. 2019; Paparella *et al*. 2022). The tree is endemic to and widely cultivated on the coasts of Mediterranean countries such as Turkey, Morocco, Israel, Greece, Portugal, and other temperate and warm regions of the world (Fig. 1). This distinctive aromatic plant can grow to a height of 5 to 7 m and is found at altitudes ranging from 0 to 800 m. Turkey is responsible for almost all the world's total bay leaf production, which is 7,000 to 7,500 tons per year (Paparella *et al*. 2022). In ancient Greek mythology, laurel tree is a symbol of immortality because of its evergreen leaves.

Although high flexibility of the PBAT biopolymer film makes it well suited for food packaging applications, its weak antibacterial properties shorten the shelf life of the products, thus creating a bottleneck in the food industry. A comprehensive literature review revealed that no studies have been conducted on modifying the PBAT polymer with bay leaf essential oil to improve its antibacterial activity and thermal stability. This work aimed to improve the processability and antibacterial activity of the PBAT biodegradable film using bay leaf essential oil. For this purpose, PBAT was treated with four different amounts

(5, 10, 15, and 20 wt%) of the essential oil. The microstructural, chemical, and thermal properties, and antibacterial activities of the modified PBAT biofilms were investigated.

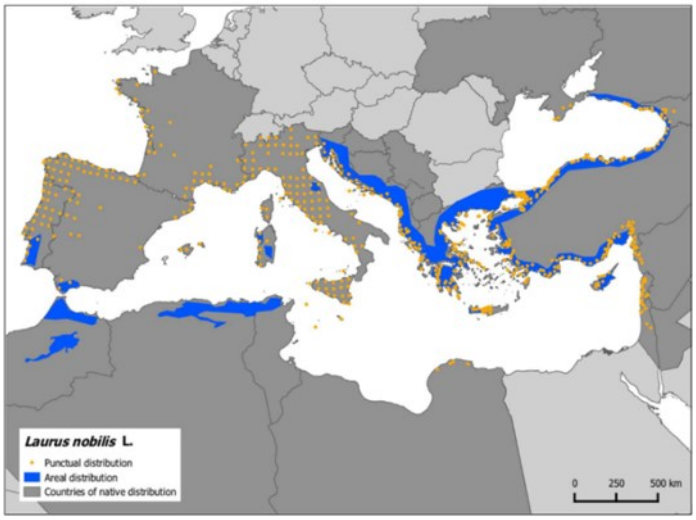


Fig. 1. Geographical distribution of bay shrub in the world

EXPERIMENTAL

Materials

The pure bay leaf essential oil (*Laurus nobilis* L.) was purchased from a local producer in Turkey. It was obtained by steam distillation of bay leaves. The virgin PBAT granules were obtained from BASF company (Ecoflex® F Blend C1200). It had density of 1.25 g/cc, melt flow index of 2.7 to 4.9 g/10 min, a number-average molecular weight (M_n) of 52.1 kg/mol, and melting temperature of 120 °C.

Production of the PBAT Films with Bay Leaf Essential Oil

Prior to processing, the PBAT was dried at 50 °C for 24 h in a binder oven (Binder company, Germany). The PBAT pellets were then melted in an internal mixer (RTX- M40, Kökbir company, Turkey) consist of a chamber to which the compounding ingredients are added. Two rotors in the chamber generate high shear forces that disperse the essential oil in the PBAT polymer. Then, the bay leaf essential oil was added and the mixture was stirred for three minutes at 160 °C at a screw rotation speed of 50 rpm. The raw material composition of the test specimens is given in Table 1.

Table 1. Weight Ratios of PBAT with Different Amounts of Bay Leaf Essential Oil

Specimen Code	PBAT (wt%)	Bay Leaf Essential Oil (wt%)
A	100	0
B	95	5
C	90	10
D	85	15
E	80	20

The biofilms of each of the formulations were obtained in a hydraulic press at a temperature of 160 °C. The PBAT particles with different amounts of essential oil were held between two plates at atmospheric pressure for 1.0 min until melting, then at 50 MPa for 3 min. As a reference material, the pure PBAT without essential oil was also processed in the same way. The production process of the biofilms is presented in Fig. 2.

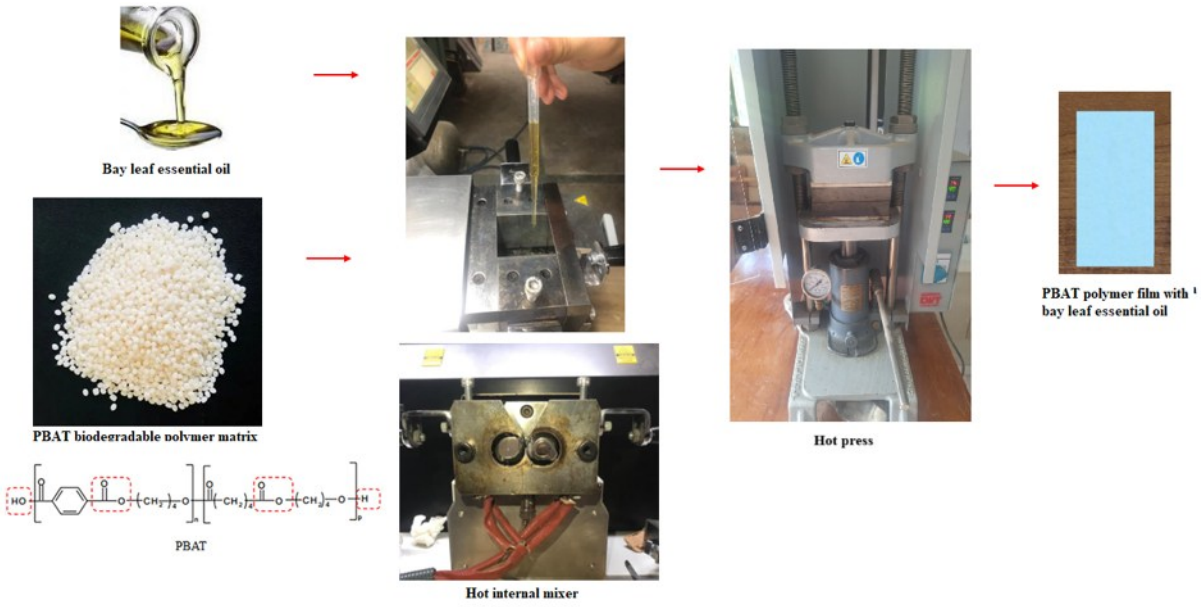


Fig. 2. The preparation of the PBAT film with bay leaf essential oil in the hot internal mixer

Fourier-Transform Infrared Spectroscopic Analysis

The functional groups involved in the bay leaf oil that were responsible for the composite material formation with PBAT film were determined by Fourier transform infrared (FTIR) analysis. The presence of chemical groups in the bio-oil was detected using the FTIR analysis (Shimadzu IRTracer-100 model LabSolutions) through an ATR (attenuated total reflectance) device in the range of 400 to 4000 cm^{-1} with a resolution of 4 cm^{-1}.

Differential Scanning Calorimetric Analysis

The thermal stability of the biofilms was determined by the differential scanning calorimetric (DSC) analysis. The thermal transitions of the specimens were carried out under two different heating rates. The initial heating stage erased the thermal history of the specimen while the second heating stage allowed for the analysis of its inherent transitions. The DSC analysis was carried out using a Perkin Elmer-DSC-8000 instrument (Massachusetts, USA) under a nitrogen atmosphere. The analysis was performed according to the following procedure:

1. Initial heating: The specimen was heated from 25 to 300 °C at a rate of 10 °C/min. The purpose of this step was to obtain the thermal history of the specimen.
2. Cooling: After the initial heating, the specimen was cooled back to 25 °C at a controlled cooling rate. This step allowed the specimen to return to its initial temperature.
3. Second heating: The specimen was reheated from 25 to 300 °C at the same heating rate of 10 °C/min. This second heating step provided data on the inherent thermal transitions of the specimen, without the influence of its previous thermal history.

Determination of the Essential Oil Components by GC–MS Analysis

The volatile compounds of the bay leaf essential oil were determined by the gas chromatography–mass spectrometric (GC-MS) analysis. The essential oils of the bay leaves were determined using an Agilent 5975 GC-MS instrument (Agilent Technologies, Little Falls, CA, USA), which was controlled *via* the ChemStation Data Analysis program. Helium gas was employed as mobile phase at a rate of 1 mL/min, and the injections were executed in splitless mode at 240 °C. A solution of essential oil in hexane (GC grade) was injected, with a volume of 1 µL. The temperature of the column was set to vary from 60 to 240 °C at a rate of 4 °C/min, with the lower and upper limits set to 2 and 10 min, respectively. The individual mass spectra for each volatile compound were obtained after the separation of the compounds from the GC-column. The process of identifying the compounds involved a comparison of the mass spectra of each component with reference compounds from the NIST libraries. The retention times of the identified compounds were then compared with literature data (Adams 2007).

Antibacterial Activity of Biofilms

The following strains were inoculated into Mueller-Hinton Broth (MHB):

- Gram-positive: *Staphylococcus aureus* Rosenbach (ATCC 6538) and *Bacillus cereus* (ATCC 7064)
- Gram-negative: *Escherichia coli* (ATCC 8739) and *Salmonella typhimurium* strains

The Müller-Hilton agar (MHA) was used to test for antibacterial activity against bacteria, while the malt extract agar (MEA) was used to test for yeast strain. The strains were then inoculated into sterile petri dishes using a 0.5 McFarland standard and incubated at 37 ± 1 °C for 1 h (CLSI 2012; Balouiri *et al*. 2016). Amikacin (AK: 30 µg) and Gentamicin (CN: 10 µg), which are aminoglycoside antibacterial agents, were used as the control.

The antibacterial property of the samples was carried out using the Kirby-Bauer disc diffusion technique (Bauer *et al*. 1966; Murray *et al*. 1999). The samples were prepared as 1 cm × 1 cm discs and placed on cultures of bacteria in MHA and yeast strains in MEA. To determine the zones of inhibition, the samples were then incubated at 37 °C for between 18 and 24 h (Bradshaw 1992; David and McCuen 1998; CLSI 2012; Balouiri *et al*. 2016). Three specimens were used in the experiments and the mean values were calculated.

RESULTS AND DISCUSSION

GS-MS Analysis of the Essential Oil

The GS-MS analysis of bay leaf essential oil is presented in Fig. 3. The results of the GC-MS analysis revealed a total of 38 chemical components in the bay leaf, which are given in Table 2. When the main components were analyzed, the highest ratio was determined as 1,8 Cineole with 48.18%, followed by Carene with 8.21%, Sabinene with 5.73%, 4-Terpinol with 4.85%, α-Pinene with 4.35%, β-pinene with 3.53%, α-Terpineol with 2.65%, Myrtenol with 2.32% and others (Table 2). The essential oil was found to be very rich in monoterpenic hydrocarbons and monocyclic monoterpenes such as 1,8-Cineole, α-Terpinen-4-ol constituted the largest fraction.

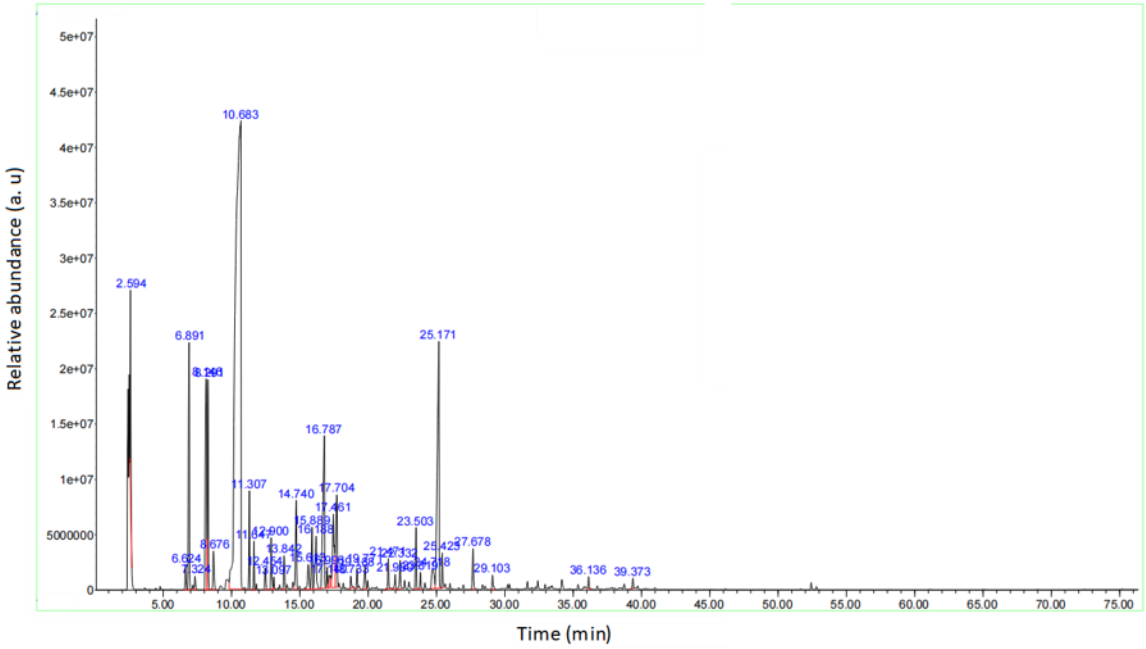


Fig. 3. GC-MS analysis of bay leaf essential oil

Table 2. Results of the GC-MS Analysis

Number	RT (min)	Scientific Name	Area (%)
1	2.594	Cyclohexane	2.05
2	6.622	Thujene	0.45
3	6.891	α-Pinene	4.35
4	7.326	Camphene	0.24
5	8.144	Sabinene	5.73
6	8.293	β-Pinene	3.53
7	8.676	1,8-Cineole	0.88
8	10.685	1,8-Cineole	48.19
9	11.309	Terpinene	1.19
10	11.646	*cis*-Sabinene	0.60
11	12.453	α-Terpinolene	0.48
12	12.899	*cıs*-Sabinene	0.82
13	13.100	Ictatrien-3-ol	0.16
14	13.843	Camphene	0.72
15	14.742	*trans*-Pinocarveol	1.94
16	15.611	β-Phorone	0.68
17	15.886	Pinocarvone	1.14
18	16.189	*p*-Mentha-1,5-dien-8-ol	1.61
19	16.785	4-Terpinol	4.85
20	16.996	α-Thujenal	0.32
21	17.139	*p*-Cymen-8-ol	0.30
22	17.460	α-Terpineol	2.65
23	17,706	Myrtenol	2.32

Number	RT (min)	Scientific Name	Area (%)
24	18.730	*trans*-Carveol	0.22
25	19.188	*cis*-*p*-Mentha-1(7),8-dien-2-ol	0.29
26	19.771	Benzaldehyde, 4-(1-methylethyl)	0.52
27	21.471	4-Thujen	0.49
28	21.980	Bornyl acetate	0.28
29	22.335	*p*-Cymen-α-ol	0.54
30	23.502	Sabinene	1.00
31	23.817	3-Ethylidene-4,4-dimethyl-5-methyl	0.28
32	24.715	Acetaldehyde	0.94
33	25.173	Carene	8.21
34	25.425	Eugenol	0.53
35	27.679	Hyl eugenol	0.08
36	29.104	2,5-Diacetylfuran	0.29
37	36.136	Caryophyllene	0,22
38	39.375	2-Naphthalenemethanol	0.18

FTIR Analysis

FTIR spectra of PBAT films, both neat and combined with different concentrations of bay leaf essential oil (5-20 wt%) are shown in Fig. 4. The spectra exhibited characteristic peaks corresponding predominantly to the PBAT backbone.

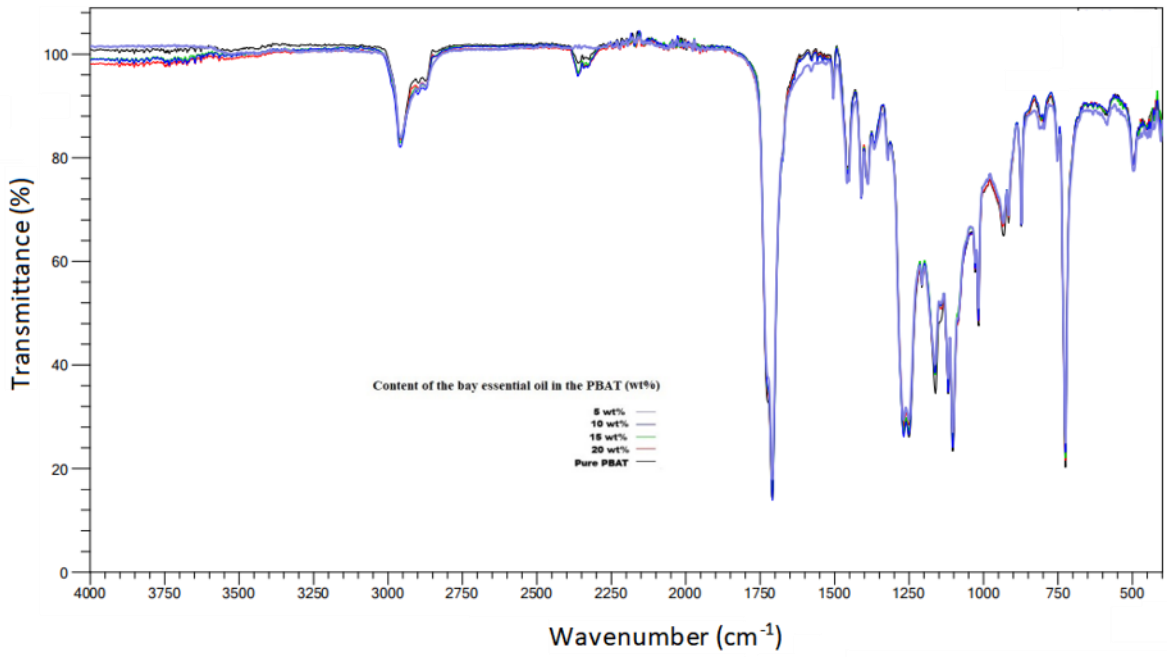


Fig. 4. FTIR spectra of bay leaf oil and PBAT films containing different amounts of bay leaf oil

The major absorbances included a strong ester C=O stretching (1720 to 1730 cm^{-1}) and aliphatic C-H stretching (2950 and 2850 cm^{-1}). Additional PBAT peaks were observed for C-H bending (about 1450 cm^{-1}), C-O stretching of ester groups (1270 cm^{-1} and 1100 cm^{-1}), and aromatic C-H "out-of-plane" bending (730 cm^{-1}). No significant new absorbance

bands or significant shifts in existing peak positions were noted with the addition of the essential oil, suggesting that the primary chemical structure of PBAT was not greatly affected. While weak interactions between PBAT and the essential oil components are possible, they do not cause detectable changes in vibrational modes by FTIR at these concentrations. Therefore, the essential oil is likely to diffuse through the polymer matrix *via* physical interactions and not form new covalent bonds or cause significant structural rearrangements (Chacha *et al*. 2022).

DSC Analysis

The DSC results of the PBAT films with and without the essential oil of bay leaf are given in Table 3. The phase change behaviour of the pure BPAT polymer was investigated between 0 and 250 ºC using a differential thermal calorimeter. Two phase changes were observed when heating the PBAT copolymer up to 250 °C. These phase changes were identified as endothermic peaks. The first phase change occurred within the 41 to 65 °C range, and the second within the 103 to 148 °C range. Heat uptake of 4.73 J/g and 10.81 J/g of enthalpy was realized in the first and second phase changes, respectively. The endothermic peak observed during cooling in the 103 to 140 °C range appeared as an exothermic peak in the 98.8 to 118.3 °C range. The other phase changes occurred without transformation. The crystallization peak temperature was found to increase with the addition of bay leaf oil to the PBAT polymer. This is related to the crystallization rate constant. The addition of bay leaf oil increased the crystallization rate of the PBAT film. No change in the number of endothermic or exothermic peaks was observed with the addition of bay leaf oil at levels of 5, 10, 15 and 20 wt% compared to pure PBAT polymer. A similar result was observed by Filho *et al*. (2022). They reported that the degradation temperature of the studied films was not affected by the presence of the oils. In the present study, it was determined that the realized phase transitions were PBAT polymer. Adding the bay leaf oil to the PBAT polymer only affected the temperature range of the phase transitions, causing them to increase or decrease.

Table 3. Results of the DSC Analysis

Bay leaf oil content in PBAT film (phr)	First melting peak temperature (ºC)	Crystallization peak temperature (ºC)	Second melting enthalpy (J/g)	Second melting peak temperature (ºC)	Crystallization enthalpy (J/g)	X_c Crystallinity (%)
0	52.9	98.8	10.8	131.9	10.2	9.5
5	55.5	96.3	10.6	131.3	13.0	9.8
10	55.6	98.3	9.7	130.6	12.2	9.5
15	56.1	101.8	8.6	129.1	13.4	8.9
20	57.1	100.1	7.9	126.8	11.5	8.7

An increase in the amount of essential oil resulted in a decrease in the melting temperature (T_m) of the PBAT, showing that the essential oil had a good plasticizing effect (Fig. 5). The melting temperature of pure PBAT was found to be 131.9 °C, decreasing to 126.8 °C when the essential oil content reached 20 wt%. A considerable decrease was observed when the essential oil content increased from 15 to 20 wt%. This result was expected, as plasticizers generally increase polymer chain mobility, thus facilitating chain folding for the transition from a disordered to an ordered state (Varghese *et al*. 2020). The decrease in the X_c values of the PBAT films with increasing essential oil content could be

related to impurities such as amino acids and aromatic compounds, which were identified in the FTIR spectra.

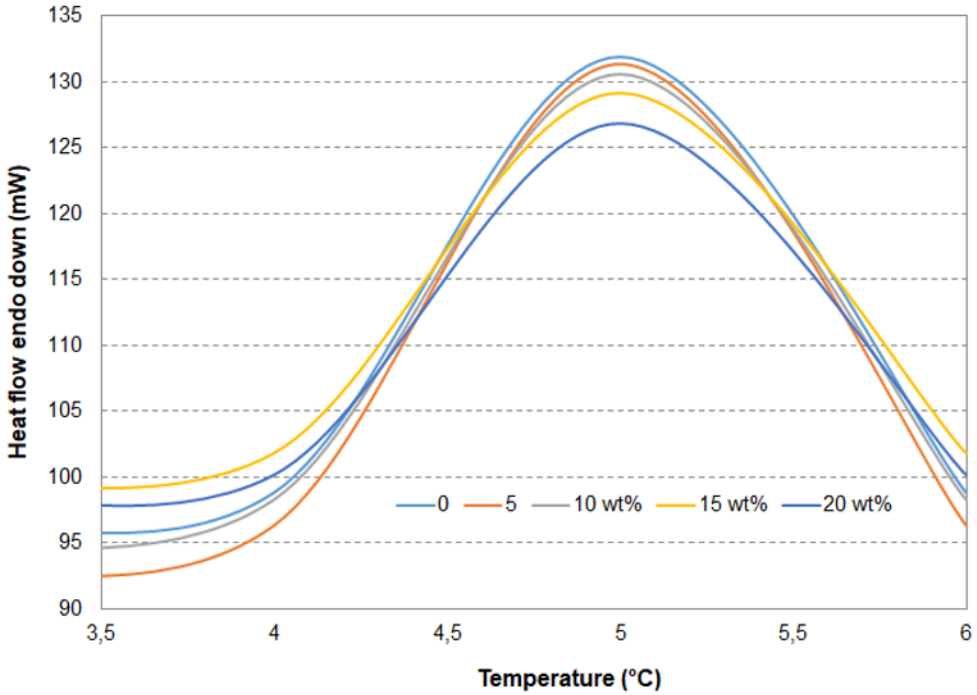


Fig. 5. The second melting (peak) temperatures of the PBAT polymer with increasing amount of bay leaf extracts

Antibacterial Activity

The antibacterial activity of the PBAT films treated with different amounts of the bay leaf essential oil are shown in Table 4. The antibacterial activity of the PBAT films increased with the addition of essential oil. According to the test results, the PBAT films containing more than 10 wt% of the essential oil showed inhibition zones of 8 to 12 mm in diameter against Gram-positive, Gram-negative, and yeast strains.

Table 4. Antibacterial Activity Values of the Sample (mm)

Specimen code	Gram negative		Gram positive	
	Escherichia coli	*Salmonella typhimurium*	*Staphylococcus aureus*	*Bacillus cereus*
0	0	0	0	0
5	0	0	0	0
10	0	0	0	0
15	8	8	12	8
20	12	12	12	8
Amikacin	24	28	28	30
Gentamicin	18	22	22	20

0: No zone was observed.

In addition to the neat PBAT film, the PBAT films containing 5 and 10 wt% bay leaf oil did not exhibit antibacterial activity against the Gram-positive bacteria *Staphylococcus aureus* and *Bacillus cereus*, or the Gram-negative bacteria *Escherichia coli* and *Salmonella typhimurium*. According to the results of the study, the control PBAT films did not exhibit any activity against the *C. albicans* strain. It was determined that the 20% sample showed a zone diameter of 12 mm against the *E. coli* strain. Similarly, it was found that the sample exhibited a zone diameter of 12 mm against the *S. aureus* strain. The PBAT biofilm, with 20 wt% bay leaf oil was found to have the lowest antibacterial effect, at 8 mm, against the *B. cereus* and *S. typhimurium* strains. These different findings are thought to be due to the unique cell wall structure of each strain.

The main chemical component of bay leaf, 1,8-Cineole, is thought to be responsible for its antibacterial properties. This has been confirmed by previous studies (Karık *et al*. 2015; Sırıken *et al*. 2018; Sobhy *et al*. 2023; Merghni *et al*. 2023; Akacha *et al*. 2024). It was concluded that the strong antibacterial activity of bay leaf essential oil is due to the synergistic effect of components such as terpenes (linalool), lactones, monoterpenes (camphene and α-pinene) and oxides (1,8-cineole) (Merghni *et al*. 2023). Bay leaf essential oil exhibits antibacterial activity against the *Eurotium*, *Aspergillus*, and *Penicillium genera* (Sırıken *et al*. 2018). These results were consistent with those of previous studies (Sırıken *et al*. 2018; Sobhy *et al*. 2023; Akacha *et al*. 2024). The antifungal activity of bay leaf essential oil varies depending on its constituent compounds. Essential oil compounds with hydrophilic functional groups and/or lipophilicity exhibit more dominant antibacterial properties against Gram-positive bacteria than Gram-negative bacteria (Mukurumbira *et al*. 2023). No single specific mechanism has been proposed for the antibacterial activity of essential oils as this depends on the constituents and concentrations of the oils, as well as the nature of the bacteria.

CONCLUSION

This study investigated the use of polybutylene adipate-co terephthalate (PBAT) polymer film, a biodegradable polymer, at different ratios to improve the antibacterial properties of bay leaf oil, which has an important market in the food sector. According to the differential scanning calorimeter (DSC) results, bay leaf oil was found to have a plasticizing effect when added to the PBAT polymer. Gas chromatography-mass spectrometry (GC-MS) analysis revealed a total of 38 components in bay leaf leaves, primarily 1,8-cineole (48.18%), carene (8.21%) and sabinene (5.73%). The monoterpenic hydrocarbons, sesquiterpenes, and monocyclic monoterpenes in the essential oil were found to be effective in terms of antibacterial activity. The antimicrobial activity of the PBAT film increased considerably against gram-positive, gram-negative bacteria and yeast strains, with inhibition zones measuring 8 mm and 12 mm in diameter when the bay leaf oil content was 15 wt% and 20 wt%, respectively. The results showed that bay leaf essential oil could be used as a natural preservative to increase food safety and extend the shelf life of packaging film and other biomedical applications. Future study will focus on the static and dynamic mechanical properties of the PBAT films containing the essential oil.

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