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Research Article

ANTIBACTERIAL BIOPLASTIC PRODUCTION WITH HERBAL EXTRACT

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Abstract

Plastic is the general name given to solid materials that are suitable for the production of industrial materials, have a wide usage area, synthetic or semi-synthetic, light, easily shaped and high chemical resistance. Petroleum-derived plastics are the most used and most important in the world. It is seen that the excessive production and consumption and the unconscious pollution of the environment increase in direct proportion. Since such plastics stay in the environment for a long time, the importance of plant-based plastic production is increasing. It is thought that the biodegradation time of plant-based plastics is short and it increases the quality of the living and non-living things in the environment instead of harming them. It can be produced with the desired durability, desired shape and flexibility like petroleum-based plastics in bioplastics. Although bioplastic production has come to the fore in recent years, the rate of bioplastic production remains lower due to the fact that petroleum-based plastic production is more factory-made. The increase in the use of chemical-containing plastics triggers the health of living things and global warming. It is thought that it is important to seek solutions by using antibacterial plants instead of using chemicals. If the antibacterial properties of herbal extracts can be brought to the fore, it is thought that the shelf life of the product can be increased. In this study, the water absorption capacity of the containers, the bacteria formation, the percentage of dissolution in nature and the density results were tested. It has been determined that the produced bioplastics inhibit microbial growth and extend the shelf life of the product.

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Bitkisel Özlü Antibakteriyel Biyoplastik Üretimi

Özet

Plastik, endüstriyel maddelerin üretimine uygun, geniş kullanım alanına sahip sentetik ya da yarı sentetik, hafif, kolay şekil verilebilen ve yüksek kimyasal dayanıklılığı olan katı malzemelere verilen genel isimdir. Dünya genelinde en çok kullanılan ve en çok öneme sahip olan petrol türevli plastiklerdir. Üretimin ve tüketimin fazla olması ile çevrenin bilinçsizce kirletilmesinin doğru orantılı olarak arttığı görülmektedir. Bu tür plastiklerin çevrede uzun süre kalmasından dolayı bitkisel özlü plastik üretiminin önemi artmaktadır. Bitkisel özlü plastiklerin doğada çözünüm sürelerinin kısa olduğu, çevredeki canlı ve cansız varlıklara zarar vermek yerine onların kalitesini arttırdığı düşünülmektedir. Biyolastiklerde petrol bazlı plastikler gibi istenilen dayanıklılıkta, istenilen şekilde ve istenilen esneklikte üretilebilir. Son yıllarda biyoplastik üretimi ön plana çıksa da petrol bazlı plastik üretiminin fabrikalaşmasının fazla olmasında dolayı biyoplastik üretim oranı daha düşük kalmaktadır. Kimyasal içerikli plastiklerin kullanımının artması canlı sağlığını ve küresel ısınmayı tetiklemektedir. Kimyasal kullanımı yerine antibakteriyel özellikli bitkilerden faydalanarak çözüm aranmasının önemli olduğu düşünülmektedir. Bitkisel özlerin antibakteriyel özellikleri ön plana çıkarılabilirse ürün raf ömrünün artırılabileceği düşünülmektedir. Yapılan bu çalışmada kapların su alma kapasitesine, bakteri oluşumuna, doğada çözünme yüzdelerine ve yoğunluk sonuçları test edilmiştir. Üretilen biyoplastiklerin mikrobiyal üremeyi engellediği ve ürün raf ömrünü uzattığı tespit edilmiştir.

Anahtar Kelimeler
Biyoplastik
Papaya
Beyaz lahana
Antibakteriyel
Raf ömrü

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1. INTRODUCTION

Plastic is the general name given to solid materials suitable for the production of industrial materials, synthetic or semi-synthetic [1, 2] with a wide range of uses, light, easily shaped, high mechanical properties, high chemical resistance, transparent and available in different colors [3].]. The most important and most used materials we use throughout our lives are plastics, which are petroleum-derived polymers. Approximately 150 million tons of plastic are produced worldwide. With the increase in plastic demand in recent years, the oil consumption required for plastic production also increases at the same rate. Unconscious use and disposal of the produced plastics cause environmental pollution as they are not soluble in nature. Storage areas are needed to reduce the environmental pollution of waste materials. Considering its production, this area should be built on a very large land [4, 5, 6, 7] Since the recycling of these wastes can take several centuries, environmental health is adversely affected. In addition, the components (chloride, lead, etc.) in some of the plastics produced can cause diseases such as endocrine disorders, immune system and cancer [8]. Solid waste production in the world decreased by 0.74 kg/day per person in 2016, while a total of 2.01 billion tons of solid waste is produced. With the rapid increase in population and urbanization, this rate is expected to increase by 70% and reach 3.40 billion tons in 2050. Today, while at least 150 million tons of petroleum is used for one-year petroleum-based synthetic plastic production, over 500 million tons of toxic chemicals are used. The burning of these waste materials, which are insoluble or difficult to dissolve in nature, causes the emergence of some harmful chemicals such as dioxin, which has a share in global warming [2, 9, 10] The negative effects of produced plastics on global warming and environmental health have reached levels that cannot be corrected by recycling studies to be carried out for centuries. . For these reasons, many countries are in search of new searches that can be easily removed from the biosphere and that will eliminate the negative effects of environmental damage and global warming. Many countries are trying to recycle their plastic waste. Countries such as Germany, Austria, Sweden, the Netherlands and Denmark have managed to recycle 85-100% of their plastic waste, while the European average remains at only 28% [11]. Since this rate is low worldwide, the use of organic plant-based plastics, which are easily biodegradable and renewable, should be highlighted.

It is necessary to develop and produce nature and life-friendly plastics known as bioplastic or bio-degradable plastics, as the plastics produced from petroleum have reached dimensions that will adversely affect nature and living life. According to the production methods, bioplastics are examined under 3 headings: production from renewable resources (plant/animal), petroleum-derived, biological origin and petroleum-mixed [12]. The use of plant-based substances (starch, cellulose, wood, castor oil and sugar, etc.) instead of fossil fuels used in the production of bioplastics is accepted in terms of reducing carbon emissions, reducing greenhouse gases and sustainable economic [13]. In addition, it is thought that while bioplastic with herbal essence dissolves in nature physically and chemically, it will not adversely affect the living spaces of the living things around it [14]. There are studies on the acceleration of bioplastic dissolution in nature by fungi [15]. According to 2014 data, while 325 million tons of petroleum-based plastics were produced, only 5 million tons of bioplastics were produced. Although the production of bioplastics is increasing day by day, it has lagged behind petroleum-based plastics [11]. While the wide production range of petroleum-based plastic reduces the cost, the narrowness experienced in the production area of bioplastic increases the production cost and prevents the development of bioplastic [13]. Recently, studies have been carried out to reduce the cost of bioplastics. Global warming and the increase in environmental pollution have started to increase the demand for bioplastics. In the

USA and European Union countries, the use of herbal biodegradable products in packaging production has started to be compulsory [16]. It has been observed that bioplastics can be applied in many areas with their mechanical and water absorption properties. When the literature was searched, bioplastics were produced considering the proteins found in potatoes and rice. By mixing the obtained proteins with different glycerol concentrations, bioplastics with thermal decomposition temperature between 60 and 180^{o}C were produced [17]. Bioplastics differ from petroleum-based plastics in that they are easily degraded, the energy consumed for their production is low, and they are environmentally friendly by reducing the dependence on petroleum [18].

According to the World Health Organization, 80% of the global population uses medicinal plants for their health care. Throughout history, medicinal plants have been used in the fields of medicine, spice, dye, food, tea, veterinary treatment and cosmetics. Medicinal plants have been found to have antioxidant, antibacterial, antiviral and antifungal effects thanks to many secondary metabolites [19].

White cabbage (*Brassice oleraceae* var. Alba) is grown on the coasts of the North Sea, Western Ireland, France, Spain, Italy, in East Asia and in every region of our country. Cabbage cultivation, flowering period and the optimum temperature for them to form a head is 15-20^{0}C, which helps to form the head [20]. Cabbage leaves contain sugar, proteins, fats, vitamins such as C, P, B1, B2, B6, K, D, carotene, enzymes, mineral salts, antibacterial agent - lysozyme components.

Carica papaya L. (Papaya) is a plant belonging to the *Caricaceae* family and has four different genera: Carica, Farilla, Cylicomorpha and Facaratia. While other genera other than Carica are used for decorative purposes, Carica papaya leaves, fruit, seeds, flowers and roots are used by humans for food and medicinal purposes. C. papaya is a plant species in tree form that can be grown widely in tropical and subtropical regions. Due to the commercial importance of the fruit and its papain content, it is widely cultivated [21, 22]. Papaya fruit is rich in iron, calcium, potassium, vitamins A and B. It is thought that papaya seeds show antibacterial properties and protect themselves against insects. It is known that after the Kunaya people dried and pulverized the papaya seeds, both humans and farm animals suffered from parasitic disorders in the intestines [21]. The seeds of papaya fruits constitute 7% of the fruit. It has been found that cysteine in the papaya plant reduces the egg secretion and the amount of worms by more than 97% at every stage of the developing plant from arthropod pests, plant parasitic nematodes and infection that may occur in the plant [23].

The hawthorn plant takes local names such as Akdiken, May thorn, deer thorn. Hawthorn is a species belonging to the Rosaceae family. There are 20 species of hawthorn in our country and 50 species known in the northern hemisphere [24]. Hawthorn is a woody plant species in the form of evergreen, thorny bush or shrub that sheds its leaves in winter [23, 24, 25, 26]. It is known that hawthorn fruits are important for human health. In addition, hawthorn is a species that has a very important place in terms of the sustainability of wildlife [27]. Extracts of hawthorn fruits are recommended to be consumed for human nutrition and health and have been approved by the health ministry of many countries [28].

2. MATERIAL AND METHOD

In this research, it was aimed to produce herbal-based antibacterial bioplastics using the experimental method. (You have to explain how many repetitions the experiments were made.)

2.1 Preparation of Herbal

The seeds of papaya are kept in pure water for a week. White cabbage leaves are boiled and the water obtained is taken. To prepare Container B, add 60 milliliters of distilled water (add cabbage juice for container C, papaya seed juice for container D, and cabbage and papaya seed juice for container E, into a heatproof container. 10 grams of corn starch, 5 milliliters of homemade hawthorn vinegar and vegetable glycerin are added to it. The resulting solution is mixed. When the prepared mixture is translucent, it is shaped and left to cool without waiting for it to cool.Tthe research was carried out with five different containers (Table 1).

Table 1. Please put heading of the table

Petroleum-based plastic (A)	Bioplastic prepared with pure water (B)	Bioplastic prepared with White Cabbage juice (C)	Bioplastic prepared with papaya seed juice (D)	Bioplastic prepared with papaya seed juice + white cabbage juice (E)

The application groups were determined as a result of the literature review. As a result of the research, he drew attention to the fact that antibacterial bioplastics were not produced.

2.2 Efficiency of Herbal

Studies have been carried out on petroleum-based plastic and 4 different bioplastics obtained. Cheese molds of the same weight and opened at the same time were added to each bowl. The bacteria formation times of cheese molds and the effect of antibacterial properties were examined for 60 days. (Figure 2) (You have to explain which bacteria and mold species have been identified and used in your experiment)

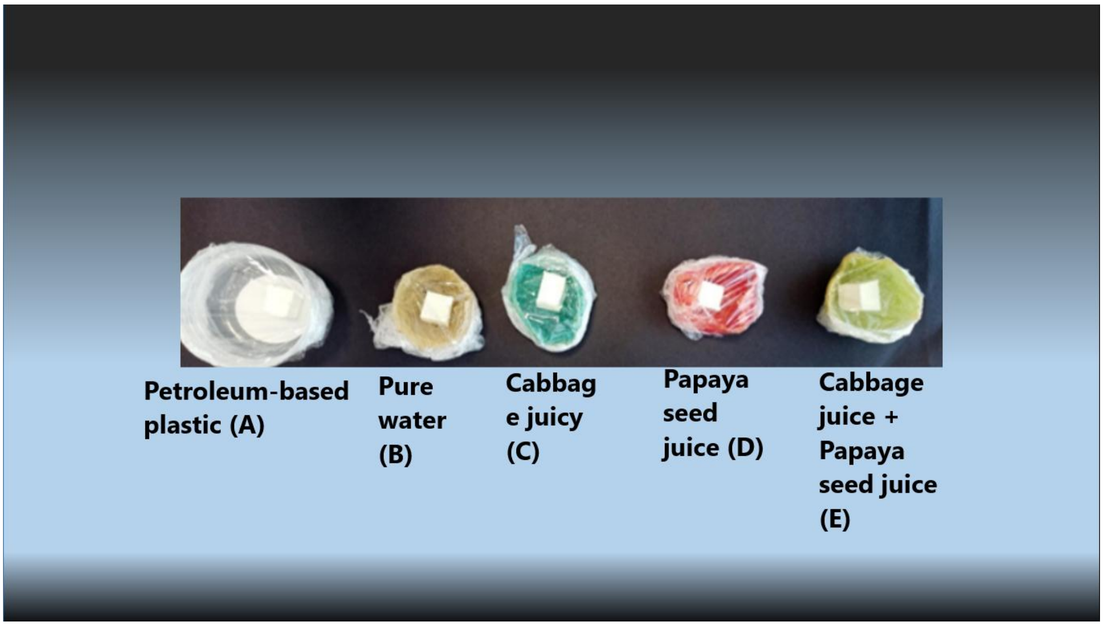

Figure 2. A visual from the product shelf life (bacteria formation) study is indicated.

2.3 Endurance Test

The durability levels of the obtained bioplastics were examined. The dissolution processes of plant-based plastics produced in this process in nature (15 days in water and soil environment) were examined. Plastic and bioplastic parts added to the media were used in such a way that they were of equal weight (Figure 3). Experiments were performed in triplicate. The averages of the obtained data were taken.

2.4 Percentage of Water Intake

After the first weights of the samples were taken, the same samples were kept in water for 24 hours, and the water uptake (%) values of the bioplastics whose weighing measurements were taken were calculated according to the formula given below.

$$SA=[(My-Mk) / Mk] \times 100$$

Mk = Initial weight of the sample (g); My = Weight of the sample after soaking (g); SA = water uptake rate (%).

2.5 Density test (g/cm^3)

Density test is calculated according to ASTM D 792 standards. No sizing has been made for the sample size here. First of all, the dry weights of the samples under laboratory conditions were weighed. Then the wet weights were calculated. The obtained data were calculated with the following formula.

$$\text{Density } (g/cm^3) = [Mk/My]$$

Here; Mk = Dry weight of sample (g); My = The wet weight of the sample is given as (g).

2.6 Statistical Analysis

The averaged data were calculated by statistical analysis of variance method (SPSS, ANOVA) by performing 3 replications for each group.

3. RESULTS AND DISCUSSION

3.1 Degradation times of plastics

The nature 15-day dissolution rates of petroleum-based and plant-produced bioplastics were examined. (A: Petroleum-based container, B: Pure water container, C: Cabbage water container, D: Papaya seed water container, E: Cabbage juice + papaya seed juice). 15-day biodegradation percentages of the Containers were given in Figure 3.

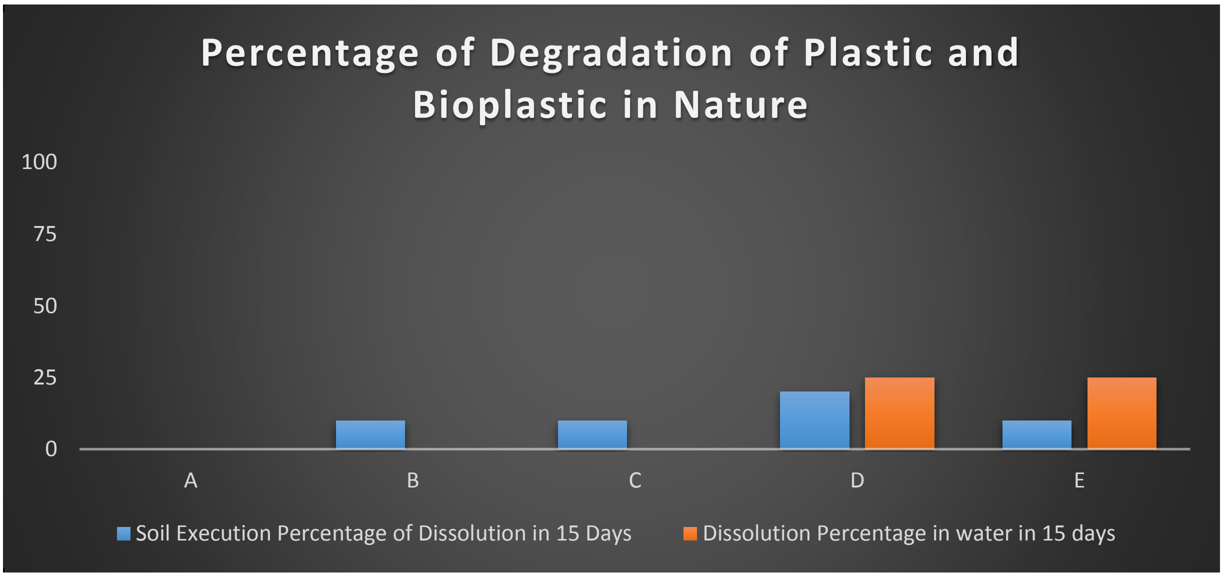

Figure 3. Percentage of Degradation of Plastic and Bioplastic in Nature

The biodegradation percentages of plastics and bioplastics were calculated. The cases examined in the 15-day period are stated as a percentage. It was determined that it did not dissolve in the A, B and C containers in the water environment, and 25% dissolved in the D and E containers. Considering their solubility in the soil environment, they are listed as D, E, C, B and A. Again, no dissolution was observed in vessel A. The rapid biodegradation reactions of the obtained bioplastics indicate that they are environmentally friendly. In a study, the water solubility percentages of E (25% corn starch), F (50% corn starch), and G (75% corn starch) samples, which are bioplastics with red pine wood, were determined as 5.88%, 10.3% and 9.84%, respectively [29] . Bioplastics are more environmentally friendly than conventional plastics [30].

3.2 Effect of plastics on shelf life of food (Bacteria formation)

The effects of petroleum-based and plant-produced bioplastics on the shelf life of foods were investigated. (A: Petroleum-based container, B: Pure water container, C: Cabbage water container, D: Papaya seed water container, E: Cabbage juice + papaya seed juice) Bacteria formation results of cheeses kept for one year were calculated. The shelf life (bacteria formation) of the product according to the containers is indicated (Figure 4).

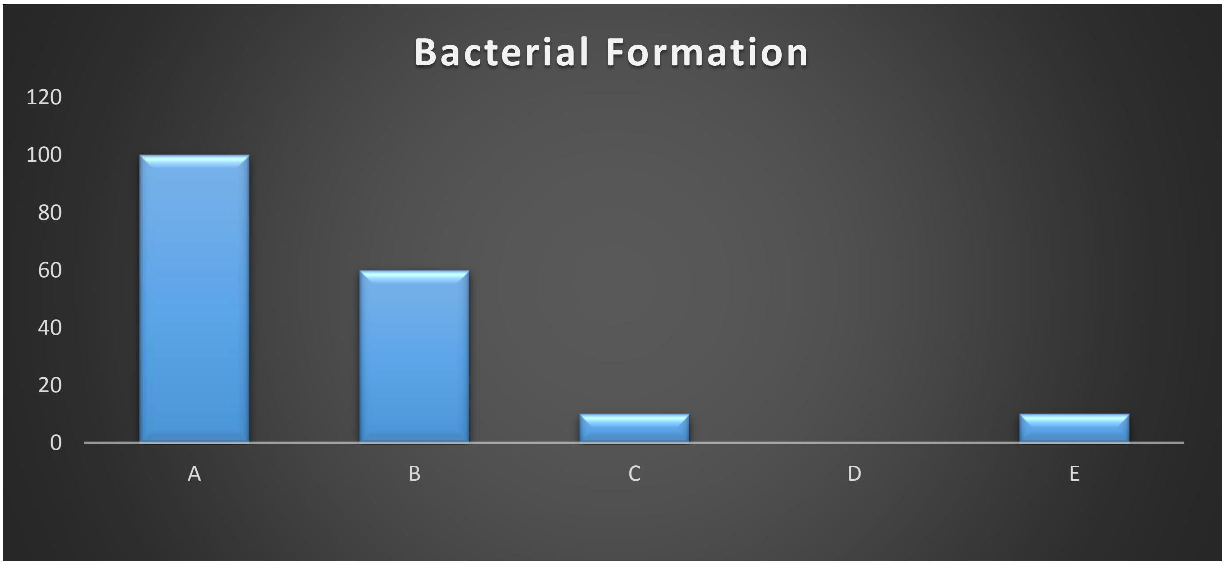

Figure 4. Bacterial growth in plastics and bioplastics

It was determined that no bacterial formation was observed in bioplastics prepared with papaya seed juice. In petroleum-based plastic, bacteria formation was detected within 7 days. It is thought that papaya seeds show antibacterial properties and protect themselves against insects. Kunaya people are known to suffer from parasitic disorders in the intestines of both humans and farm animals after drying and pulverizing papaya seeds [28]. Cabbage leaves contain sugar, proteins, fats, vitamins such as C, P, B1, B2, B6, K, D, carotene, enzymes, mineral salts, antibacterial agent - lysozyme components. Figure 5 shows the bacterial growth of the products in the container.

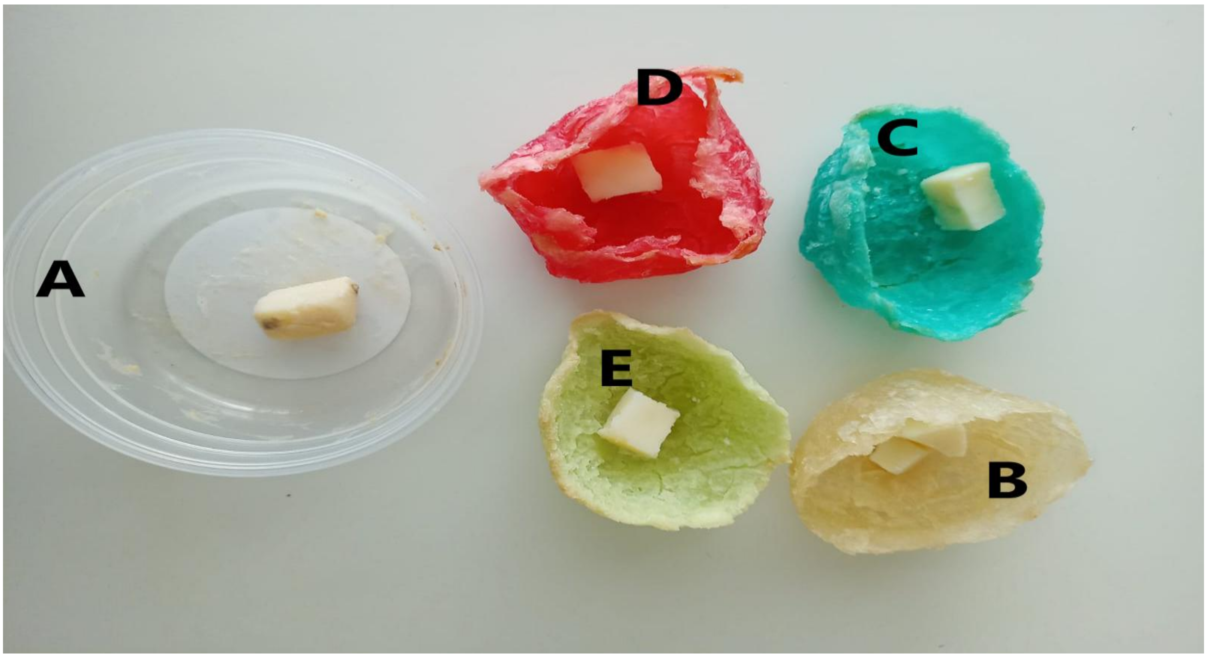

Figure 5. Investigation of microbial formation in plastics and bioplastics

3.3 Dewatering percentages and density testing of plastics

The water uptake percentages and densities of petroleum-based and vegetable-produced bioplastics were determined. (A: Petroleum-based container, B: Pure water container, C: Cabbage water container, D: Papaya seed water container, E: Cabbage juice + papaya seed juice). The density test results of the containers are indicated (Figure 6).

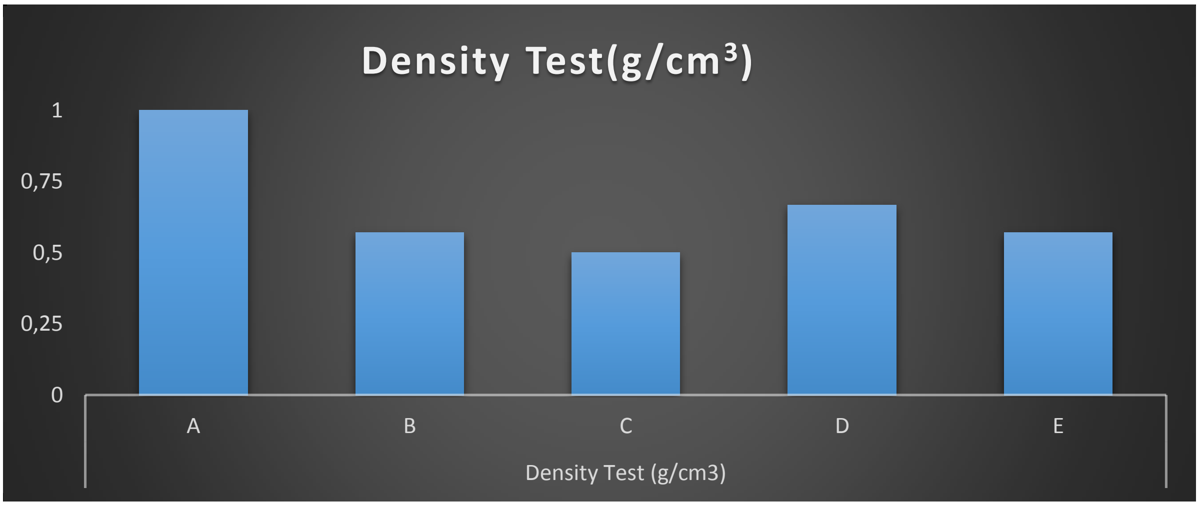

Figure 6. Density results of plastics and bioplastics

When the density of the containers is examined, the bioplastic prepared with cabbage juice comes to the fore. C bioplastic prepared with cabbage juice can be preferred when it is aimed to produce a low density bioplastic. It is known that the density of plastics produced with corn starch is high. However, it was determined that the bioplastic prepared with cabbage juice (C) was lighter. This may be due to the hydrophilic nature of cabbage juice, which surrounds the hydrophobic starch [29]. It may be due to the fact that the spaces between the starch particles increase the distance between the particles and reduce the amount of mass. The results of the water uptake percentages of the containers are given (Figure 7).

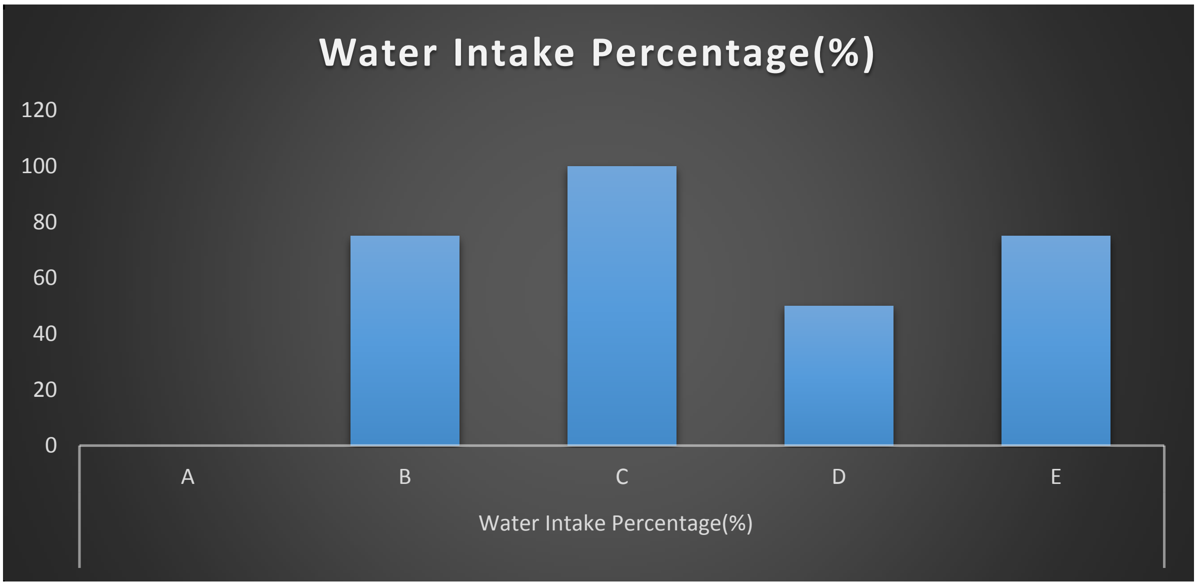

Figure 7. Water intake percentages of plastic and bioplastic containers

When the water intake percentages of the containers are examined, bioplastic prepared with papaya seed juice comes immediately after petroleum-based plastic. It shows that the D container is preferable with its resistance in the aquatic environment.

4. RESULTS

With this research, the 15-day dissolution time of plastics in nature, the effect of plastics on shelf life (bacteria formation for 1 year), the percentage of water uptake of plastics and the densities of plastics were investigated.

The dissolution rates of plastics in water for 15 days were determined as E 25%, D 25%, C 0%, B 0%, A 0%. The dissolution rates of the same plastics in the soil for 15 days were determined as D 20%, E 10%, C 10%, B 10%, A 0%. Accordingly, it takes an average of 500-1000 years for petroleum-based plastics to disappear from nature. However, when we look at the responses of bioplastics within 15 days, it has been determined with the data obtained that the dissolution time in nature is short.

In the experiment, the effect of plastics on the one-year shelf life of cheese was investigated. Accordingly, the shelf life of the food, that is, the bacteria formation period, started to occur in the A container for 7 days and at the end of one year, 100% bacteria formation was detected. In bowl B, 60% bacteria formation was detected after 250 days. In a one-year period, 20% bacterial growth was detected in containers C and E and 0% in dishes D. Accordingly, it was determined that the bacterial formation of bioplastics prepared with cabbage juice, papaya seed juice and cabbage juice + papaya seed juice did not occur for a long time.

Density states of plastics were calculated. Accordingly, the densities of the containers were determined as 1 g/cm3, container B 0.57 g/cm3, container C 0.50 g/cm3, container D 0.66 g/cm3 and container E 0.57 g/cm3, respectively. has been done. C, B, E, D and A results were obtained when their densities were ordered from smallest to largest. When light bioplastic production is desired, cabbage aqueous bioplastic can be advantageous.

The water intake faces of the plastics were calculated. Accordingly, the water intake percentages of the containers were determined as 0% for A container, 75% for B container, 100% for C container, 50% for D container and 75% for E container. It is thought that the reason why the water intake capacity of the C container is the highest is due to the hydrophilic feature of the cabbage. In the same situation, it is observed that the percentage of water uptake is highest in container C (cabbage juice), but this ratio decreases with papaya seed juice in container E (cabbage juice + papaya seed juice). When the prepared bioplastics were examined, the water intake percentage of the D container was the lowest. It is seen that the papaya seed used in the D container increases the water intake resistance. According to these data, it is thought that papaya seed aqueous plastic may be preferred instead of petroleum-based plastic in the aquatic environment.

When the data obtained are examined, it is seen that bioplastics are environmentally friendly and have a positive effect on the shelf life of the product. With this research, attention was drawn to the production of antibacterial bioplastics and significant results were obtained. According to these data, D container (papaya seed juice) comes to the fore as a result of dissolution times, bacteria formation, water intake and density tests. C (Cabbage juice) and E (cabbage juice + papaya seed juice) containers can also be used. It is thought that the antibacterial properties of the homemade hawthorn vinegar used in the production of these bioplastics also have an effect. This effect is seen in B (pure water). When the findings are examined, it is thought that the production of antibacterial bioplastics can be made. This method is thought to protect the environment and be sustainable.

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