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Evaluation of the Effect of Chitosan-Based Edible Film and Coating Material on Dried Mulberry

Eda GÜNEŞ[1], Haticetül Kübra ERÇETİN[2*]

[1,2]Necmettin Erbakan University, Faculty of Tourism, Department of Gastronomy and Culinary Arts, Konya

[1]https://orcid.org/0000-0001-7422-9375
[2]https://orcid.org/0000-0001-7935-4052
*Corresponding author: htk.kubra@gmail.com

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ABSTRACT

The purpose of applying coating methods in the study is to slow down the chemical deterioration that will occur in foods. The effect of the model organism, which is considered as a warehouse pest, on the coated mulberry was determined. At the end of storage, weight, texture and sensory analyzes of the fruit were made. Sensory analyzes were evaluated by 20 semi-trained panelists in terms of color, appearance, hardness, taste, smell, general taste. In terms of weight, it was observed that the weight of 1% chitosan coated mulberries was higher. In terms of texture, although the groups were statistically similar ($p>0.05$), it was determined that the hardness of the samples in the environment with storage pests decreased somewhat. According to sensory data, it was determined that the panelists had a positive approach towards 0.2% coated mulberry. As a result, the edible coating is considered to be useful for mulberries.

Kitosan Bazlı Yenilebilir Film ve Kaplama Materyalinin Kurutulmuş Dut Üzerindeki Etkisinin Değerlendirilmesi

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ÖZ

Kaplama yöntemlerinin çalışmada uygulanmasındaki amaç, gıdalarda oluşacak kimyasal bozulmayı yavaşlatmaktır. Depo zararlısı olarak değerlendirilen model organizmanın kaplamalı dut üzerine etkisi belirlenmiştir. Depolama sonunda meyvelerin ağırlık, tekstür ve duyusal analizleri yapılmıştır. Duyusal analizler 20 yarı eğitimli panelist tarafından renk, görünüm, sertlik, tat, koku, genel tat açısından değerlendirilmiştir. Ağırlık olarak ise %1 kitosan kaplı dutların ağırlığının daha yüksek olduğu görülmüştür. Tekstür açısından gruplar istatistiksel olarak benzer olmasına rağmen (p>0,05), depolama zararlılarının bulunduğu ortamda örneklerin sertliğinin bir miktar azaldığı tespit edilmiştir. Duyusal verilere göre panelistlerin %0,2 kaplamalı duta olumlu yaklaştıkları belirlenmiştir. Sonuç olarak, yenebilir kaplamanın dutlarda kullanılabilir olduğu düşünülmektedir.

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1. Introduction

Mulberry is native to China, although in many parts of Asia; it is widely grown in Japan, Korea, Manchuria, India, Pakistan, Iran and Anatolia (Gokmen, 1973; Ozbek, 1977; Baskaya, 2013). Therefore, mulberry is grown as a suitable product for many soil and climatic conditions. In the records of FAO (Food and Agriculture Organization), although the mulberry production fluctuates by years, it is stated as 69,317 tons in 2020 (Anonim, 2020).

Widely consumed mulberry varieties are *Morus nigra* L. (Black Mulberry), *Morus rubra* L. (Purple Mulberry), *Morus alba* L. (White Mulberry) and *Morus levigata* (Finger Mulberry) (Imran et al., 2010).

Mulberry is produced in every region of Turkey, except for six provinces (Kahramanmaraş, Adıyaman, Elazığ, Erzincan, Malatya and Tokat) where production is insufficient to be included in statistics. According to TUIK statistics, the total mulberry production in Turkey in 2020 was 66.647 tons (TUIK, 2020). It has been stated that white mulberries account for 95% of all mulberry species cultivated in the country, while red mulberries account for 3% and black mulberries account for 2% (Ercıslı, 2004; Orhan, 2009).

Fruit is a frequently consumed product in Turkish cuisine. Simultaneously, mulberry fruit has an important place in the production of fruit pulp and köme products, which are traditionally made and commercially produced today (Savkay, 2000; Efendi, 2005; Yıldız, 2013; Yerasimos, 2014; Akkor, 2014; Guldemir, 2016; Kuzucu, 2016). In addition, products such as molasses, jam, mulberry paste, ice cream production, walnut sausage, vinegar, fruit juice concentrate, spirit are also produced from the fruit (Serceoglu, 2014). Mulberry fruit can be consumed fresh and dried. Sources include dried and fresh mulberry dishes, and mulberry rice and black mulberry dessert are an example (Koymen, 1982; Arlı, 1982; Sahın, 2008; Kozleme, 2012; Gursoy, 2013; Yerasimos, 2014; Samancı, 2016; Demirgül, 2018; Isın, 2018). Produced using dried mulberry, mulberry tea powder is used in making donuts, biscuits, cakes and bread in China (Huo, 2000; Machii, 2002). Mulberry fruit is a good source of energy with a high nutritional content. The protein content of the fruit varies between 4.72% and 9.96%; it is counted among fruits rich in phytochemicals, monoterpenes and polyphenols (flavonol and anthocyanin) (Srivastava et al., 2006; Zhang et al., 2018). However, fresh mulberry with high moisture content is difficult to preserve due to the short harvest period and storage sensitivity (Doymaz, 2004). Packaging becomes a necessity to ensure the continuity of safety and reliability until the consumption stage, to preserve its quality and nutritional properties and to preserve its properties during the projected shelf life (Gennadıos et al., 1997; Vermeıren et al., 1999; Krochta, 2002). Edible films and coatings are used today as an environmentally friendly application to extend the shelf life of foods and to preserve the quality properties of foods (Baldwin, 1994; McHugh, 2000; Keles, 2002; Han and Gennadıos, 2005; Falguera et al., 2011; Galus and Kadzińska, 2015).

Sugary foods are among the products that pose the highest risk in terms of food safety during the storage phase. Especially, biological contamination elements such as insects cause product losses as warehouse pests and affect many quality characteristics of the product such as taste, appearance, odor and texture. In the study, the preferred model (*Drosophila melanogaster*) as a storage pest is fed with chitosan-coated mulberries and is important for the preference of the coating material, for the evaluation of living things and the environment. Due to the high sugar content of dried mulberry fruit, it is resistant to storage pests and deteriorates quickly. Because sugar crystals formed on dried fruits encourage the reproduction of storage pests (Aksoy et al., 2004). In the study, the effect of the coating material formed with the chitosan solution on the mulberry (such as weight, texture and sensory analysis) was determined and its shelf life was extended. In addition, consumer opinions were taken through sensory analysis and the marketability of the coated product was evaluated.

2. Materials and Methods

In this study, dried mulberry grown in central Anatolia Konya commercially available mulberries (*M. alba*) in 2019/2020 were used. *D. melanogaster* (Oregon) culture has been cultivated in the laboratory of with an artificial diet (Rogina and Helfand, 2000) since 2014 (60%-70% humidity and 25 ± 2˚C).

2.1. Preparation of coating material

The solution was prepared from 10 g of commercial chitosan with 1% acetic acid and 0.5% glycerol and mixed in a magnetic stirrer (Bandelin, Germany) for two days. The chitosan ratios used were set at 0.2%-2% (Kahve, 2016; Sımsek and Keyf, 2018). Chitosan solutions homogenized for one hour at 40˚C were exposed to ultrasonic washing for 30 min to remove gas (Carbonell-Capella et al., 2015). The prepared chitosan solution was coated on the entire surface of the dried mulberry fruit using the spraying method (airbrush, Artos Power). All chemicals were supplied from Sigma-Aldrich.

2.2. Implementation of the harmful model

The experimental setup was kept in the incubator (Core ES120) in the same environment with the culture, insects were followed until they became mature. 50 individuals (25 females and 25 males) of the same age and unpaired were transferred to the experimental setup that did not show any maturation, and their survival was followed, and the dead insects were removed from the experimental design. In order to survive for insects, mulberry and insect in the food environment were taken into a new bottle every two days and egg laying was prevented. The trials continued for a month.

2.3. Weight and texture analysis

Before and after the experiment, four fruit samples were selected from each trial design, weighed (Ohaus PA-214C) and averaged. Fruits were photographed by scanning their surface areas under a microscope to determine external tissue changes (Olympus SZ61; X 2.5).

For texture analysis, a texture device (Texture Analyzer TAXT2I; stable microsystems). Texture profile analysis (TPA) was performed. For TPA, the diameter of penetration probe was used as a 5 mm; five samples were selected separately for each group in the trial design. The texture was measured from two opposite points of each fruit. For each application, the average of 10 (10 x 10) measurements was taken. In determining the hardness, the penetration force (N) was measured with a cylinder probe with a diameter of four mm, a velocity of one mm/s and a penetration distance of 7.5 mm from the middle points of the mulberry with the compression program of the texture analyzer.

2.4. Sensory analysis

In the chitosan solution prepared for sensory analysis, the solution was prepared using the same ratio of vinegar instead of 1% acetic acid. The sensory properties of edible coated fruit were evaluated with a Hedonic scale by 20 semi-educated panelists (20 semi-trained panelists with food training) without prior information. Samples were independently rated above five points in terms of color, appearance, taste, odor, hardness and general taste. Samples were independently rated more than 5 points in terms of color, appearance, taste, odor, hardness and general taste (5: excellent; 4: good; 3: acceptable; 2: not sufficient; 1: bad) (Beğen, 2012). The application was in two repetitions.

2.5. Analysis of data

One-way analysis of variance (ANOVA) and Duncan Multiple Comparison Test (Duzgunes et al., 1987) were compared using statistical program (LSD and Duncan test) to determine the difference between the means of homogeneous and normally distributed groups. In the analysis results of the samples, the difference between the applications was determined. Mann Whitney U test was used to compare storage hardness of mulberries (no table given in the text). Analysis were repeated twice; The significance of the means is shown in the tables and figures at a probability level of 0.05 and standard errors (ST) are given.

3. Results

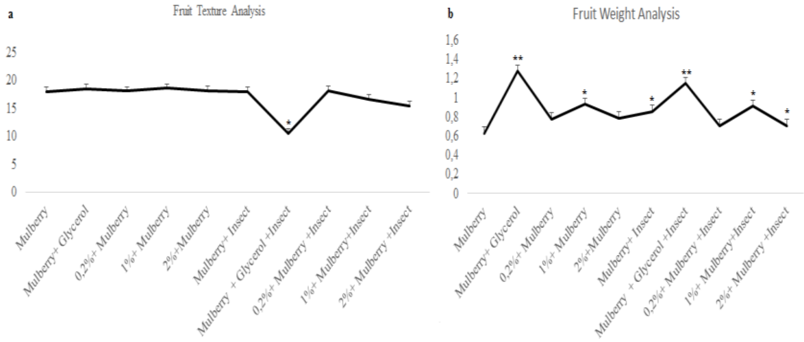

Figure 1. a. Mulberry texture analysis, **b.** Mulberry weight analysis ($p < 0.05$)

According to the texture analysis applied on mulberries, the hardness was decreased as depending on the ratio of the coating material and a negative correlation was created on fruits. While fruit firmness was 18.01 ± 0.1 N in the control group (Figure 1; the lowest hardness in coated fruits was measured in mulberries coated with glycerol (10.5598 ± 0.1 N). The gel-like structure of glycerol, softening the mulberry fruit directly reduces the fruit hardness. Among the mulberries with no living organisms, the lowest hardness was measured in mulberries covered with a 2% chitosan solution (15.6646 ± 0.1 N). Near normal (control) hardness of 18.2417 ± 0.1 N was measured in mulberry coated with 0.2% chitosan solution (Figure 1).

Figure 2. Morphological images of mulberries after pretest without coating and coating **a.** Uncoated mulberry, **b.** Mulberry coated with glycerol, **c.** Mulberry covered with 0.2% chitosan, **d.** Mulberry covered with 1% chitosan, **e.** Mulberry covered with 2% chitosan.

Due to the glycerol weight, glycerol-coated mulberry (1.15 ± 0.02 g) was the highest weight, while 0.2% coated mulberry (0.71 ± 0.01 g) was the lightest group after the control (0.63 ± 0.01 g).. There was no correlation between these groups in terms of weight (b>c>a) (Figure 2). Covered mulberries for sensory analysis are seen in Figure 3.

Figure 3. Mulberries; **a.** Mulberry with a coating with 1% grape vinegar, **b.** Mulberry with a coating added with 0.2% grape vinegar, **c.** Mulberry with 2% grape vinegar coating applied, **d.** Uncoated mulberry

Table 1. Sensory analysis results of edible film-coated mulberries

Examples	Color			Appearance			Taste			Smell			Hardness			General Rating		
	Mean ± S.H.	Sig.	t test	Mean ± S.H.	Sig.	t test	Mean ± S.H.	Sig.	t test	Mean ± S.H.	Sig.	t test	Mean ± S.H.	Sig.	t test	Mean ± S.H.	Sig.	t test
Mulberry	3.17±0.2	0.1**	11.9	3.40±0.2	0.15*	12.14	3.47±0.2	0.5	15.24	3.70± 0.2	0.1*	16.90	3.05±0.2	0.46	11.3	3.32±0.2	0.3*	13.77
0.2% Mulberry Coated Chitosan	3.62±0.2	0.4*	16.0	3.67±0.2	0.24*	15.7	3.45±0.2	0.3*	14.19	3.62±0.2	0.1*	17.42	3.17±0.2	0.80	10.6	3.70±0.1	0.2*	22.58
1% Mulberry Coated Chitosan	3.22±0.2	0.5	12.2	3.10±0.2	0.30*	13.0	3.25±0.2	0.6	11.51	3.50±0.2	0.64	16.54	3.05±0.2	0.83	13.6	3.32±0.2	0.5	15.43
2% Mulberry Coated Chitosan	3.30±0.2	0.3*	15.7	3.26±0.2	0.60	12.9	3.21±0.2	0.9	11.74	3.60±0.2	0.68	15.38	2.85±0.2	0.86	10.1	3.51±0.2	0.9	16.58

***Degrees of importance**

Within the scope of sensory evaluation, panelists evaluated the color, appearance, taste, odor, stress and general taste of edible film-coated mulberries (Table 1). When the appearance of the coated mulberry is examined, there is no difference except for the gel-like structure (Figure 2). However, when the colors of the mulberries covered with 2% grape vinegar were evaluated, a significant difference was observed ($p<0.05$). Panelists said that 0.2% coated mulberries are better in terms of color, appearance and taste.

4. Discussion

Microbial growth can be destroyed in dried fruits, but vegetative cells and spores can survive for a long time (Beuchat et al., 2013). Microbial growth that occurs, a significant quality deterioration on fruit; moisture adsorption, oxygen invasion, flavor loss, unwanted odor absorption and migration of packaging components to food cause mass transfer events (Fennema and Sherman, 1976; Kester and Fennema 1986; Debeaufort et al., 1998; Krochta, 2002). Due to the high sugar content in dried fruits the growth of microorganisms occurs rapidly during storage (Beuchat et al., 2013). The main purpose of use of edible films and coatings is to minimize and eliminate the presence of pathogenic microorganisms in foods. The effect of edible coatings on dried fruits with high sugar content, which was also used in study, is the subject of many studies (Azeredo et al., 2009; Rojas-Grau et al., 2009; Deng et al., 2011; Lago-Vanzela et al., 2013; Garcia et al., 2014; Farahmandfar et al., 2017). Glycerol was added to the coating at the preparation stage to reduce the brittleness and extensibility of the coating used in the study (Hernandez-Izquıerdo and Krochta, 2008; Gounga et al., 2010; Tonyalı et al., 2018). In addition, *D. melanogaster* was used to determine the effects of nutrients, which have a short growth biology, whose nutritional requirements are known quantitatively (Sang, 1956), and which are used in obesity studies, on non-target organisms and target agricultural pests (Tettweiler et al., 2005).

According to texture analysis, the lowest hardness on fruits has been stated on mulberries coated with glycerol (10.5598 ± 0.1 N). The decrease in the hardness of the samples with glycerol compared to the mulberry without coating shows that the gel-like structure of glycerol directly affected fruit hardness. Simultaneously, it was determined that the weight of glycerol mulberry (1.15 ± 0.02 g) was the highest due to the weight of glycerol. Accordingly, it was determined that the insect considered as a storage pest did not decrease the weight of the fruit among the application groups as show in Figure 1, but increased the weight of the mulberry with coating.

The most important negativity that occurs during storage in dried fruits is browning and it is assumed that the different colors of the mulberry used in sensory analysis application affect the panelists (Fennema and Sherman, 1976; Cemeroglu and Ozkan 2004). Studies have reported that the use of film solution prepared with chitosan as a coating material has an important effect on improving the sensory properties of foods (Vargas et al., 2006; Han et al., 2014). A study with freeze-dried carrots indicates that samples immersed in citric acid solution are more liked by panelists in terms of general acceptability in sensory evaluation, and are similar to study (Erbay et al., 2009). When the colors of the mulberries covered with 2% grape vinegar were evaluated, a positive difference was observed (Table 1). It is thought that uncoated mulberries are liked more than grape vinegar in terms of taste, and the difference in odor is due to the stronger smell of grape vinegar compared to the uncoated product. Similarly, it has been stated the panelists that strawberries coated with whey protein are acceptable (Karabulut et al., 2018). It has been stated that the general quality of bananas coated with gum arabic and chitosan is preserved and bananas with 1% chitosan solution are acceptable in sensory evaluation (Maqbool et al., 2011).

5. Conclusion

In the study; the usability of chitosan solution as edible material has been tested on fruit, storage pest and sensory analysis to reduce and eliminate that the quality deterioration occur in fresh and dried fruits. In terms of weight, it was observed that the weight of 1% chitosan coated mulberries was higher. Although the groups were statistically similar in terms of texture, it was determined that the hardness of the samples decreased somewhat in the presence of storage pests. Panelists said that 0.2% coated mulberries are better in terms of color, appearance and taste. The study was planned considering that the fruit, whose coating materials are high in sugar, will serve as a packaging in terms of its life in the warehouse and on the shelf. According to the data obtained, it was determined that the amount of chitosan used is important in increasing the shelf life of dried fruits and minimizing quality deterioration.

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Conflict of Interest Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the article.

References

Aksoy U., Meyvacı BK., Sen F., Altindisli A. Impact of fumigants applied to control storage pests on fruit quality of dried figs. Integrated Protection of Stored Products IOBC Bulletin/WPRS, 2004;

27: 203-208. Akkor YE. Gelenekten evrensele Osmanlı mutfağı. Alfa Yayınları, Baskı 2, İstanbul; 2014.

Anonim. https://www.tarimorman.gov.tr/sgb/Belgeler/SagMenuVeriler/BUGEM.pdf Erişim Tarihi 05.06.2020.

Arlı M. Türk mutfağına genel bir bakış, Türk Mutfağı sempozyumu bildirileri. Kültür ve Turizm Bakanlığı Milli Folklor Araştırma Dairesi Yayınları, Ankara; 1982.

Azeredo HM., Mattoso LHC., Wood, D., Williams, TG., Avena-Bustillos, RJ., McHugh TH. Nanocomposite edible films from mango puree reinforced with cellulose nanofibers. Journal Food Sciences 2009; 74(5): N31-N35.

Baldwın EA. Edible coatings for fresh fruits and vegetables: Past, Present and Future. In Baldwin EA., Hagenmaier R., Bai J., Krochta JM. (Eds.), Edible Coatings and Films to Improve Food Quality 1994; 25-64.

Baskaya Z. Gelişimi ve dağılışı bakımından türkiye ipekböcekciliğinde bilecik ilinin yeri, sorunları ve çözüm önerileri. Doğu Coğrafya Dergisi 2013; 18-30.

Begen F. Yüksek lif içerikli bisküvi üretiminde lüpen (*Lupines albus l.*) kepeği kullanımı üzerine bir araştırma. Selçuk Üniversitesi, Konya, 2012.

Beuchat LR., Komitopoulou E., Beckers H., Betts RP., Bourdichon F., Fanning S., Ter Kuile BH. Low-water activity foods: increased concern as vehicles of foodborne pathogens. Journal Food Protection 2013; 76: 150-172.

Carbonell-Capella JM., Buniowska M., Esteve MJ., Frígola A. Effect of stevia rebaudiana addition on bioaccessibility of bioactive compounds and antioxidant activity of beverages based on exotic fruits mixed with oat following simulated human digestion. Food Chemistry 2015; 184: 122-130.

Cemeroglu B., Ozkan M. Kurutma teknolojisi. In Cemeroğlu, B. (Eds.), Meyve ve Sebze Işleme Teknolojisi. Başkent Klişe Matbaacılık, Ankara, 2004.

Debeaufort F., Quezada-Gallo JA., Voilley A. Edible films and coatings: tomorrows packagings. A review. Critical Reviews Food Sciences 1998; 38: 299-313.

Demirgül F. Çadırdan saraya Türk mutfağı. Uluslararası Türk Dünyası Turizm Araştırmaları Dergisi 2018; 3, 105-125.

Deng Q., Penner MH., Zhao Y. Chemical composition of dietary fiber and polyphenols of five different varieties of wine grape pomace skins. Food Research International 2011; 44, 2712-2720.

Doymaz I. Drying kinetics of white mulberry. Journal of Food Enggineering and Technology 2004; 61: 341-346.

Duzgunes N., Allen TM., Fedor J., Papahadjopoulos D. Lipid mixing during membrane aggregation and fusion: why fusion assays disagree. Biochemistry 1987; 26(25): 8435-8442.

Efendi T., Aktürk AI. Osmanlı mutfağı. Dönence yayınları, İstanbul; 2005, ISBN: 9789757054504.

Erbay B., Kivrak E., Orhan H., Küçüköner E. Dondurarak kurutulmuş havuç dilimlerinin renk, rehidrasyon özellikleri ve bazı duyusal özellikleri üzerine farklı antioksidan çözeltilerin etkisi. Journal of Applied and Natural Science 2009; 13, 3.

Ercıslı S. A short review of the fruit germplasm resources of turkey. Genetic Resources and Crop Evolution 2004; 51, 419-435.

Falguera V., Quintero JP., Jiménez A., Muñoz JA., Ibarz A. Edible films and coatings: structures, active functions and trends ın their use. Journal of Food Science and Technology 2011; 22(6): 292-303.

Farahmandfar R., Mohseni M., Asnaashari M. Effects of quince seed, almond, and tragacanth gum coating on the banana slices properties during the process of hot air drying. Food Science & Nutrition 2017; 5, 1057-1064.

Fennema E., Sherman JA. Fennema-sherman mathematics attitudes scales: instruments designed to measure attitudes toward the learning of mathematics by females and males. Mathematics Education Research Journal 1976; 7, 324-326.

Galus S., Kadzińska J. Food applications of emulsion-based edible films and coatings. Trends in Food Science and Technology 2015; 45, 273283.

Garcia CC., Caetano LC., de Souza Silva K., Mauro MA. Influence of edible coating on the drying and quality of papaya (Carica papaya). Food Biology Technology 2014; 7, 2828-2839.

Gennadıos A., Hanna MA., Kurth LB. Application of edible coatings on meats poultry and seafoods: a review. Lwt-Food Science Technology 1997; 30, 337-350.

Gomen H. Kapalı tohumlular. Şark Matbaası, Ankara; 1973.

Gounga ME, Xu SY., Wang Z. Film forming mechanism and mechanical and thermal properties of whey protein isolate-based edible films as affected by protein concentration, glycerol ratio and pullulan content. Journal of Food Biochemistry 2010; 34, 501-519.

Guldemir O. Yemekler uygulama örnekleri Osmanlı mutfağı, Eskişehir: Anadolu Üniversitesi Yayınları, Eskişehir; 2016.

Gursoy D. Tarihin Süzgecinde Mutfak Kültürümüz. Oğlak Yayınları, Istanbul; 2013.

Han C., Zuo J., Wang Q., Xu L., Zhai B., Wang Z., Gao L. Effects of chitosan coating on postharvest quality and shelf life of sponge gourd (luffa cylindrica) during storage. Scientia Horticulturae 2014; 166, 1-8.

Han JH., Gennadios A. Gıda ambalajında yenilikler. Elsevier Bilim ve Teknoloji Kitapları 2005; 239-262.

Hernandez-izquierdo VM., Krochta JM. Thermoplastic processing of proteins for film formation-a review. Journal of Food Science 2008; 73.

Huo Y. Mulberry cultivation and utilization in China. Fao Electronic Conference on Mulberry for Animal Production (Morus1-L) 2000; 11-44.

Imran M., Khan H., Shah M., Khan R., Khan F. Chemical composition and antioxidant activity of certain morus species. Journal of Zhejiang University Science B 2010; 11(12): 973-980.

Isın PM. Avcılıktan gurmeliğe yemeğin kültürel tarihi. Istanbul: Kitap Yayınevi; 2018.

Karabulut G., Efendioglu B., Kurtulus B., Turan E., Kuyumcu H., Esen S., Mehmetoglu AC. Bacillus subtilis içeren yenilebilir kaplama uygulamasinin çileğin raf ömrüne etkisi. Gıda 2018; 43, 53-63.

Keles F. Gıda ambalajlama ilkeleri. Atatürk Üniversitesi Ziraat Fakültesi 2002.

Kester JJ., Fennema OR. Edible films and coatings: a review. Food Technology 1986.

Koymen MA. Selçuklular zamanında beslenme sistemi. Türk Mutfağı Sempozyumu Bildirileri: Ktb Yayınları, 1982; 33-45.

Kozleme O. Türk mutfak kültürü ve din. Rağbet Yayınları, Istanbul; 2012.

Krochta JM. Proteins as raw materials for films and coatings: definitions, current status, and opportunities. Protein-Based Films and Coatings, Boca Raton, Fla.: Crc Press; 2002.

Kuzucu K. Içecek kültürü, Osmanlı mutfağı. Eskişehir: Anadolu üniversitesi yayınları; 2016.

Lago-vanzela ES., Do Nascimento P., Fontes EAF., Mauro MA., Kimura M. Edible coatings from native and modified starches retain carotenoids ın pumpkin during drying. Lwt-Food Science Technology 2013; 50(2): 420-425.

Machii H. Evaluation and utilisation of mulberry for poultry production ın japan. Mulberry for animal production Fao Rome 2002; 241.

Maqbool M., Ali A., Alderson PG., Zahid N., Siddiqui Y. Effect of a novel edible composite coating based on gum arabic and chitosan on biochemical and physiological responses of banana fruits during cold storage. Journal of Agricultural and Food Chemistry 2011; 59(10): 5474-5482.

Mchugh TH. Protein lipid interactions ın edible films and coatings. Nanrung 2000; 44(3): 148-151.

Mıller KS., Upadhyaya SK., Krochta JM. Permeability of d-limonene in whey protein films. Journal of Food Science 1998; 63(2): 244-247.

Orhan E. Oltu ve olur ilçelerinde yetiştirilen dutların (*morus* spp.) seleksiyon yoluyla seçimi ve seçilen tiplerde genetik akrabalığın rapd yöntemiyle belirlenmesi. Atatürk Üniversitesi, Erzurum, Türkiye, 2009.

Ozbek S. Genel meyvecilik. Çukurova Üniversitesi Ziraat Fakültesi Yayınları: Adana; 1977.

Rogina B., Reenan RA., Nilsen SP., Helfand SL. Extended life-span conferred by cotransporter gene mutations ın drosophila. Science 2000; 290(5499): 2137-2140.

Rojas-grau MA., Soliva-Fortuny R., Martín-Belloso O. Edible coatings to incorporate active ingredients to fresh-cut fruits: a review. Trends in Food Science and Technology 2009; 20(10): 438-447.

Sahın H. Türkiye Selçuklu ve beylikler dönemi mutfağı. Türk Mutfağı, Kültür ve Turizm Bakanlığı Sanat Eserleri Dizisi: Ankara; 2008; 476, Samancı O. Osmanlı mutfağı. Osmanlı mutfağı, Anadolu üniversitesi yayınları: Eskişehir; 2016; 1-193.

Sang JH. The quantitative nutritional requirements of *Drosophila melanogaster*. Journal of Experimental Biology 1956; 3(1): 45-72.

Savkay T. Osmanlı Mutfağı. Istanbul: Sekerbank Savkay; 2000.

Serceoğlu N. Yöre halkının mutfak kültürünü tanıma durumunun tespit edilmesi: Erzurum ili. Journal of Tourism Gastronomy Studies 2014; 2(4): 36-46.

Srıvastava S., Kapoor R., Thathola A., Srivastava RP. Nutritional quality of leaves of some genotypes of mulberry (*Morus alba*). International Journal of Food Science and Nutrition 2006; 57(5-6): 305-313.

Tettweiler G., Miron M., Jenkins M., Sonenberg N., Lasko PF. Starvation and oxidative stress resistance in drosophila are mediated through the eif4e-binding protein, *d4E-BP*. Genes and Development 2005; 19(16): 1840-1843

Tonyalı B., Cikrikci S., Oztop MH. Physicochemical and microstructural characterization of gum tragacanth added whey protein based films. Food Research International 2018; 105: 1-9.

TTSM Standart Tohumluk Kayıt Listesi. https://www.tarimorman.gov.tr/BUGEM/TTSM/Sayfalar/Detay.aspx?SayfaId=86. Erişim Tarihi: 14.08.2019.

TUIK Türkiye Istatistik Kurumu, Tarım Alanları. http://tuik.gov.tr/PreTablo.do?alt_id=1001 Erişim Tarihi: 21.03.2020.

Vargas M., Albors A., Chiralt A., González-Martínez C. Quality of cold-stored strawberries as affected by chitosan–oleic acid edible coatings. Postharvest Biology and Technology 2006; 41(2): 164-171.

Vermeiren L., Devlieghere F., van Beest M., de Kruijf N., Debevere J. Developments ın the active packaging of foods. Trends in Food Science and Technology 1999; 10(3): 77-86.

Yerasimos M. Evliya çelebi seyahatnamesi'nde yemek kültürü. Yorumlar ve sistematik dizin, Istanbul: Kitap Yayınevi; 2014.

Yıldız O. Physicochemical and sensory properties of mulberry products: Gümüşhane pestil and köme. Turkish Journal of Agriculture and Forestry 2013; 37(6): 762-771.

Zhang H., Ma ZF., Luo X., Li X. Effects of mulberry fruit (*Morus alba L.*) consumption on health outcomes: a mini-review. Antioxidants 2018; 7(5): 69.