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Physical and Mechanical Properties of Paper Packaging in the Food Industry

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Research Article

Abstract − Consumers are constantly concerned about the safety of foods containing synthetic preservatives as well as the increasing number of diseases caused by pathogenic and spoilage microorganisms in food nowadays. The hydrophilicity and porous nature of the paper can easily cause the adsorption of water from the environment or food and become a suitable medium for the growth of microorganisms. The main problem with food wrapping paper and cardboard is that their basic properties are not fully understood. Packaging materials that come into contact with food, whose basic properties are determined by paper and cardboard tests, can be used appropriately instead of end-use. Hence, by reducing the risk of pathogens, it can contribute to the existing studies that are researched to prevent the proliferation of microorganisms. These preliminary tests are critical for active packaging, where antimicrobial agents are incorporated into the packaging material, which forms a protective layer through the vapor phase or direct contact with food. Thus, the main resource will be provided for antimicrobial packaging coated with essential oils, antimicrobial packaging with enzymes, antimicrobial packaging with bacteriocin, and antimicrobial packaging with inorganic materials. In this study, basic tests on three food contact paper samples were performed, and the results were compared. According to these results, better burst resistance and tensile strength results are seen in cardboard packaging. On the contrary, index values decreased when compared to the other paper samples. In the water resistance test, the best results were obtained on wrapping papers. Sulphite paper was the paper type with the none of highest resistance, according to the test results. In this rapidly developing technology, it is foreseen that naturally produced or naturally produced biopolymers will not play an important role in reducing environmental waste by combining them with packaging.

Keyword − *Paper packaging, base paper, food contact paper packaging*

Gıda Endüstrisinde Kâğıt Ambalajların Fiziksel ve Mekanik Özellikleri

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Araştırma Makalesi

Öz− Günümüzde tüketiciler, gıdalardaki patojenik ve bozulmaya neden olan mikroorganizmaların neden olduğu artan sayıdaki hastalıkların yanı sıra sentetik koruyucular içeren gıdaların güvenliği konusunda sürekli endişe duymaktadır. Kâğıdın hidrofilisitesi ve gözenekli yapısı kolayca ortamdan veya yiyeceklerden suyun adsorpsiyonuna neden olabilir ve mikroorganizmaların büyümesi için uygun bir ortam haline gelebilir. Gıda ambalaj kâğıdı ve kartondaki ana sorun temel özelliklerinin tam anlaşılamamasıdır. Kağıt ve karton testleri ile temel özellikleri belirlenen gıdayla temas eden ambalaj malzemeleri son kullanım yerine uygun kullanım olanağı kazanabilmektedir. Bu sayede patojen riskini azaltarak mikroorganizmaların çoğalmasını önlemek için araştırılan mevcut çalışmalara katkıda bulunulabilir. Buhar fazı veya gıda ile doğrudan temas yoluyla koruyucu bir tabaka oluşturan ambalaj malzemesine antimikrobiyal ajanların dâhil edildiği aktif ambalajlama için bu ön testler kritik öneme sahiptir. Böylece uçucu yağlarla kaplı antimikrobiyal ambalajlar, enzimli antimikrobiyal ambalajlar, bakteriyosinli antimikrobiyal ambalajlar ve inorganik malzemelerle antimikrobiyal ambalajlar için ana kaynak sağlanmış olacaktır.Bu çalışmada gıdayla temas eden 3 farklı kağıt örneğinin temel testleri yapılmış ve sonuçlar kıyaslanmıştır. Bu sonuçlara göre, en iyi patlama direnci, çekme direnci sonuçları karton ambalajda görülmektedir. Ancak diğer kağıt örnekleri ile karşılaştırıldığında indis değerleri daha düşüktür. Suya dayanıklılık testinde en iyi sonuçlar karton ambalajda görülmektedir. Sülfit kağıdı diğerleri ile kıyaslandığında, en yüksek mukavemete sahip olmayan tek kağıt türüdür. Hızla gelişen bu teknolojide, doğal olarak biyopolimer olan veya doğal olarak üretilen biyopolimerlerin ambalaj ile bir araya getirilerek çevresel atıkların azaltılmasında önemli bir rol oynamayacağı öngörülmektedir.

Anahtar Kelimeler − *Kâğıt ambalaj, baz kağıt , gıdaya temas eden kağıt ambalaj*.

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1. Introduction

Paper packaging technology has been rapidly developing in recent years, especially in the food industry. Compared to plastic, glass, and metal packaging, paper and cardboard materials stand out with their advantages as disposable materials. It is also an important criterion that the recycling process be less harmful to the environment. Wrapping papers and multi-layered cardboards are preferred, especially in fast food type foods where fast consumption is intense, such as bread and delicatessen products, in terms of ease of use, economy, and cost-effective printing with the surface coating process. One of the reasons why paper and cardboard are generally preferred in food packaging is the risk of pathogens that pose a potential danger to consumers (Sood vd. 2019; Suominen, Suihko, ve Salkinoja-Salonen 1997; Tanner, Wheaton, ve Ball 2011). Besides, consuming paper material in food packaging can inhibit spoilage and the growth of pathogenic microorganisms and contribute to improving food safety and extending the shelf life of packaged food, in addition to other barrier properties. Studies in this issue focus on suppression of pathogenic microorganisms, prolonging shelf life, protecting against loss of aroma and taste, and food safety (Bennett 1988; Hladíková vd. 2015; Sohel Rana vd. 2019). Due to the limit values for packages that come into contact with food and the regulations on active and smart packages that are likely to come into contact with nutrients. According to the European Union's Framework Regulation (EC) No. 1935/2004, there should be no transfer of contamination from food packaging materials to foodstuffs (Sood vd. 2019). More clearly, ingredients should not be transferred from food packaging materials to food in a way that would affect human health, cause an unacceptable change in the food product, or impair taste and odour (Sood vd. 2019). Antimicrobial paper packaging systems are convenient packaging material alternative as they are biodegradable and are safer than commonly used plastic packaging materials in this manner (Zaidi vd. 2022). Hence, the food industry is making great efforts to adapt to the technological market in therms of paper packaging material. With the globalization of the food trade, the need to protect the quality, freshness and safety of 'fresh' food products that are minimally processed, easily prepared and ready to eat has emerged. New technologies need to be developed to extend the shelf life of food products (Ahari ve Soufiani 2021; Dobre, Gagiu, ve Petru 2011; He vd. 2021; Nechita 2017; Shankar, Bang, ve Rhim 2019). With the increasing demand of consumers for fresh, convenient and safe food products, the need for storage of food contact products in reasonable periods creates the need for a wide working area for active and smart packaging.

Active packaging can be defined as a form of packaging in which the package, product, and environment interact to extend the shelf life of the product, improve safety, or improve sensory properties while maintaining the quality of the product. Among the various types of active packaging available, antimicrobial packaging is of paramount importance (Karam vd. 2013). These techniques are designed to prevent microorganism growth by preventing food spoilage and reducing the risk of pathogens. These include active packaging, in which antimicrobial agents are incorporated into the packaging material, which forms a protective layer through the vapor phase or direct contact with food (Karam vd. 2013). The basic principle of antimicrobial packaging is based on a kind of barrier technology. This Hurdle Technology; water activity, pH, redox potential, heat treatment, etc. By allowing the use of barriers, a combination of two or more such barriers achieves the optimum level of maximum lethality for microorganisms while minimizing damage to the nutritional and sensory properties of the food (Sofi vd. 2018). Commercially available biopolymers in packaging have been used primarily for fruits and vegetables due to their short shelf life, and relatively few studies have shown their use for fresh meat or fish products (Irkin ve Esmer 2015; Yasar vd. 2022). They found that the antimicrobial properties of the papers increased when they were coated with *Origanum majorana* L. essential oil (Yasar vd. 2022). It has been determined that the shelf life of the products is extended up to the 6th day in the papers that are packaged in minced meat and stored at +4 degrees cold (Yasar vd. 2022).

Paper is a natural carbohydrate polymer composed mainly of cellulosic materials. Structurally, it is porous, light, and provides sufficient physical strength properties. Thanks to this structure, the coating material can be applied easily and dries quickly on the surface. The porosity and hydrophilicity of the paper can easily cause the adsorption of water from the environment or food, so the paper may lose its physical and mechanical strength and become a suitable medium for the growth of microorganisms (El-Wakil vd. 2015). However, the advantages of paper materials, such as being recyclable and cost-effective, have been the driving force behind the development of new strategies to increase the oil and water resistance of paper (Gadhave v. 2022). Appropriate coating of the paper surface for packaging that comes into contact with food is important to support antimicrobial properties. Various studies have been carried out to impart antimicrobial properties to surfaces where nutrients come into contact with the paper surface. Since paper has a hygroscopic structure, it is weak against water vapor, gases, and oils. PVA, latex, etc., are often used to improve the barrier properties of paper and cardboard. Besides synthetic polymers, researchers focus on biobased materials such as chitosan, polylactic acid, natural wax-based materials, and protein-based materials (for example, whey protein and casein) and try to impart certain properties to paper, such as liquid repellency or a high oxygen or water vapor barrier (Gadhave vd. 2022). In addition, as health and environmental concerns regarding beeswax, fluorochemicals, and extrusion-based paper coatings increase, so does interest in bioabsorbable and repulpable substitutes for producing water and oil repellent coatings (Gadhave v. 2022). Such substances fill the gaps in the paper and provide the density of the cardboard materials. In recent years, surfaces have been developed using environmentally friendly, renewable, and biodegradable materials instead of synthetic materials (Aloui vd. 2011).

More studies are needed in the literature for antimicrobial technologies in paper and cardboard packaging. In this respect, it is critical to determine the basic properties of papers that come into contact with food or that will be used in the food industry. In a recent study, the basic properties of three types of paper used commercially in the paper packaging industry were compared by means of their physical properties.

2. Material and Method

Three different paper types have been selected within the scope of in this study. Papers were obtained as free samples from companies used in the food industry commercially. These three types of paper are wrapping paper, Sulphite paper, and cardboard. Physical resistance tests of paper samples were carried out in a laboratory environment at 50 ±2 % relative humidity and 23 ºC ±1 temperature, in a conditioning room according to TS 636 EN 20187 standard.

The ISO 536 standard was used to determine the weight of the papers, and the ISO 1974:2012 method was used to determine the tear resistance. As the tensile strength is specified in the ISO 1924-2 standard and the burst resistance values of the paper are specified in the ISO 2758 standard, the methods specified in the standard were used with the help of the Zwick/Roell test device. The Cobb30 test was applied for the water absorption resistance values of the papers, and these values were found in accordance with the methods specified in the ISO 535 standard. Paper samples were kept in the climatic chamber for 24 hours in accordance with ISO 187 before the Cobb30 test was performed. Each of the paper tests was conducted on 10 different papers.

3. Results and Discussion

The weights of cardboard, wrapping paper, and sulfite paper samples were found to be 110.13, 52.96, and 57.23, respectively. Tear test results are given in Table 1. The index values were compared in the results. In this way, paper resistances could be compared regardless of weight differences.

Table 1
Tearing Index of Papers (mN*m^2/g) Comparison

Paper Types	Machine Direction	Cross Direction
Cardboard	422	343
Wrapping paper	108	105
Sulphite	104	86

As can be seen from the tear index results in Table 1, it is understood that there is no fiber orientation in the wrapping paper. Tear index values in cardboard material are higher than others. The multi-layered structure of snow-ton also has an effect on this. The tear index value in both directions is higher in wrapping papers compared to sulfide paper. The high degree of tattooing in the wrapping papers is effective in producing these results.

Table 2
Burst Resistance and Indices Comparison of Papers

Paper Types	Burst Strength (kPa)	ss	Var.	Burst Index (kPa *m2/g)	ss	Var.
Cardboard	471	29	5.5	1.7	0.11	1.2
Wrapping paper	73	7.7	4.9	1.5	0.15	1.0
Sulphite	195	18	4.2	3.9	0.36	1.1

According to the burst index results in Table 2, the high index value in the wrapping papers and the high beating degree for thin papers are effective in these results. Although the burst resistance is high in cardboard material, when the index values associated with the weight values are examined, it is seen that the burst index is lower.

Table 3
Comparison of Tensile Index, Elongation, Break Length and Modulus of Elasticity of Papers

Paper Types	Statistics	Modulus of Elasticity^{X}(Gpa)	Breaking Length M.D.(km)	Breaking Length C.D.(km)	F.MAX M.D.(km) (kN/m)	F.MAX C.D.(km) (kN/m)	Elongation M.D.(%)	Elongation C.D.(%)	Tensile Index M.D.(N.m/g)	Tensile Index C.D.(N.m/g)
Cardboard	Average	2.6	6.9	5.3	2.7	4.1	2.0	3.7	52.3	26.6
	S.S.	0.1	0.16	0.04	0.05	0.05	0.08	1.89	1.6	0.4
	Var.	1.42	3.03	1.24	1.75	1.24	3.97	1.75	3.0	1.8
Wrapping paper	Average	5.9	1.5	1.2	2.5	2.5	4.5	4.1	78.5	79.4
	S.S.	1.6	2.9	0.02	0.07	0.07	0.10	0.79	5.1	1.02
	Var.	1.7	2.59	1.77	2.59	2.59	7.96	4.45	4.7	3.7
Sulphite	Average	3.6	3.8	2.0	1.8	1.1	1.0	1.2	37.0	20.3
	S.S.	1.44	0.21	0.11	0.10	0.05	0.06	0.14	2.0	1.1
	Var.	9.46	5.37	5.42	5.37	5.42	6.24	1.23	5.3	5.4

According to the tensile index results in Table 3, the high index value in wrapping papers and the high degree of beating degree for thin papers are effective. In the cardboard material, when the index values are examined, it is seen that the results are lower. However, the breaking length is higher compared to the others. This ensures that the cardboard material is suitable for use as a carrier.

Table 4
Comparison of $Cobb_{30}$ (g/m2) Values of Papers

Paper Types	$Cobb_{30}$
Cardboard	28
Wrapping paper	33

According to the $Cobb_{30}$ results in Table 4, water resistance could not be measured in the sulfide paper. The fact that sulphite paper does not provide structural water resistance and that paper size is not used is effective in these results. The high water resistance value in wrapping papers is due to the degree of beating in the papermaking process. In cardboard material, the use of internal sizing and surface sizing materials provides resistance against water.

4. Conclusion

Antimicrobial packaging is a rapidly developing technology. With increasing consumer demand for fresh, convenient, and safe food products, the need for versatile food packaging for transport and storage offers a bright future for antimicrobial packaging. Antimicrobial packaging systems can inhibit spoilage and the growth of pathogenic microorganisms and contribute to improving food safety and extending the shelf life of packaged food, in addition to other barrier properties. In this rapidly developing technology, it is foreseen that biopolymers that are naturally biopolymers or produced naturally will not play a major role in reducing environmental waste by combining them with packaging, and they are expected to be accepted more quickly from the point of view of the consumer, unlike unnatural ones. However, more studies are needed in the literature for antimicrobial technologies in paper and cardboard packaging. In this direction, it is critical to determine the basic properties of papers that come into contact with food or that will be used in the food industry.

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Yazar herhangi bir çıkar çatışması bildirmemiştir.

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