Characterization Physical, Chemical, Mechanical And Optical Properties of Paper on the Market for Dry Food Packaging Applications

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Abstract. The use of packaging for packaged food products such as dry snacks aims to protect the product from the damage process. The packaging factor is also a very vital strategy to support a successful sale in attracting buyers. The use of paper as packaging material is widely used because it is easy to print. To determine the print quality of a paper, it is necessary to know the characteristics of the types of paper on the market before determining which one is suitable for packaging. This study reports the results of testing physical, chemical, optical and mechanical properties on several types of paper on the market. Based on the results of testing several types of paper, the authors suggest that the most suitable paper for packaging materials is Art Carton paper with grammage specifications that are not too thick (0.212 mm) and heavy (232.49 gr/m^2). The values of DSA (19.22 gr/m^2) and DSM (7.943) also meet printing paper standards so as to produce clearer images when used in packaging printing. The pullout resistance value also shows good. In addition, the pH value of Art Carton is also not too acidic (pH 6) so that the prints dry faster and finally the brightness value shows the highest, which is 83.05% so that the print quality is better.

Keywords: Paper; Packaging; Physical Properties; Chemical Properties; Optical Properties and Mechanical Properties.

1 Introduction

The rapid development of technology lately has an impact on consumer demand for a product, especially packaged food products. Packaging is a container that occupies an item so that it is safe, attractive, has the allure of someone who wants to buy a product. This packaging factor is a very vital strategy to support a successful sale. In addition, packaging also has a big role to prevent and slow down the occurrence of damage to food ingredients. Damage can be classified into two, namely the first group of damage which is determined by the nature of the product and cannot be prevented by packaging, for example chemical, biochemical, physical and microbiological changes. The second group, the damage is determined by the environment and can almost entirely be controlled by the packaging used. Packaging aims to extend the shelf life of the packaged material. Currently, the types of food packaging used are very diverse, such as paper, glass, cans, plastic, and edible film [1-4]. To maintain the quality and safety of packaged products, packaging that can meet food safety standards is needed. The use of

JICOMS 2022, November 16, Jakarta, Indonesia

DOI 10.4108/eai.16-11-2022.2326149

packaging for packaged food products such as dry snacks aims to protect the product from the damage process. Currently, many types of packaging are used for dry snack products, including the types of polypropylene (PP) and paper packaging. Polypropylene is very similar to polyethylene and the properties for use are similar. Polypropylene is a strong and lightweight packaging with low vapor penetration, good resistance to grease, stable to high temperatures and quite glossy [5-9]. Polypropylene is widely used as a packaging material for food products. While paper is widely used for primary packaging (the outer part of the product). As we know that the function of packaging in addition to protecting the product also adds to the selling value of the product.

The use of paper is widely used as packaging because it is easy to print. To determine the print quality of a paper, it is necessary to know the characteristics of the types of paper on the market before determining which one is suitable for packaging. However, there is no published data regarding the characteristics of paper on the market. Given the importance of paper characteristics such as physical, optical, mechanical and chemical properties, it is necessary to collect information on the characterization of paper on the market. This information is useful for packaged food industry players, especially SMEs and home industries in carrying out packaging rebranding. In this study, it is still limited to testing only 5 types of paper, namely art paper, duplex, pink BC, art carton and yellow BC paper.

2 Research Methods

2.1. Measuring Grammage (Indonesia National Standart-SNI 0439)

By using the gravimetric method, which is to weigh the test paper with a size of 10 x 10 cm, the weight will be obtained in grams/100cm^2. Then, this number is multiplied by 100 to get the base weight in g/m^2. The tool used to test is an analytical balance. We used analytical balance tools to measure grammage.

2.2. Measuring Thickness (Indonesia National Standart-SNI 0435)

The principle of the test is by placing the paper between the two surfaces of the micrometer, the thickness of the paper can be directly read on the scale indicated by the tool in micron or millimeter units.

2.3. Measuring pH (Indonesia National Standart-SNI 0497)

The acidity (pH) of the paper is determined by the extraction method, namely measuring the concentration of the number of hydrogen ions from the solution extracted from the paper sample.

2.4. Measuring Brightness (Indonesia National Standart-SNI 0438)

The principle of the test is to measure it with the Data Color Elrepho 2000 tool and the results are immediately read in percent units.

2.5. Water Absorption Capacity (Indonesia National Standart-SNI 0499)

The method used is the Cobb60 method, namely by measuring the difference in paper weight after being moistened with dry paper in grams/m².

Cobb's formula x = 100 (a-b) (1)

Explanation: a = weight of wetted test sheet; b = unwetted test sheet weight; and x = test time in seconds.

2.6. Oil Absorption (Indonesia National Standart-SNI 0584)

By using the IGT method, which is dripping the test liquid (Dibutyl phthalate) on the surface of the paper at a certain speed, it will produce an oval-shaped print. Oil absorption is calculated based on the reciprocal of the length of the printed liquid on the test line, expressed in units of 1000/mm, under standard conditions.

2.7. Pull Resistance (Indonesia National Standart-SNI 0587)

By using the IGT test printer, it is calculated as the product of the viscosity of the ink with the print speed expressed in meters poise per second.

The formula (m poise/second) = Velocity x varnish viscosity at room temperature. (2)

2.8. Tensile Resistance (Indonesia National Standart-SNI 4737)

It was measured using the Alwetron Th-1 Tensile Tester (Standard version) which was determined with a test sample line, 200 mm long, 15 mm wide on the MD side (machine direction) and CD (latitude direction) using the Tensile Tester tool.

3 Results and Discussion

In this study, it is still limited to testing 5 types of paper, namely art paper, duplex, BC pink, art carton and yellow BC paper. In the use of paper as product packaging, it is necessary to test according to the requirements with several parameters (BSN, 2017). There are several brands for these types of paper on the market. The application of standards on food packaging is also expected to increase consumer protection. For paper characterization in this study, physical, chemical, optical and mechanical properties will be shown which are tested according to the Indonesian National Standard (SNI).

In addition to consumer protection, information from the results of this study can also be useful for packaged food industry players, especially MSMEs and home industries in the dry food sector in determining the appropriate paper packaging materials for their products. The physical properties of the paper tested in this study were grammage, thickness, water absorption, oil absorption, pulling resistance and tensile resistance. Paper is a printing material that has an inhomogeneous and irregular sheet formation, so a minimum and maximum grammage limit is needed. The grammage in this study was tested using the gravimetric method to determine the weight of the paper (grams) in per meter square, as shown in Figure 1.

The figure shows the grammage of Art Paper, Duplex, BC Pink, Art Carton and BC Yellow, respectively (96, 03; 316.13; 165.51; 232.49 and 149.14) gram/m^2 with a variance of 3.47%, respectively; 1.26%; 1.5%, 2.57% and 2.44%. The highest grammage value is indicated by duplex paper while the lowest is Art Paper, which is 96.03 gram/m^2. The variance value shows the test tolerance number. All tolerance values show < 4%, meaning that this number is still allowed for paper with a certain grammage. This is because paper is a printing material with non-homogeneous sheet formations so it is impossible to get a definite weight.

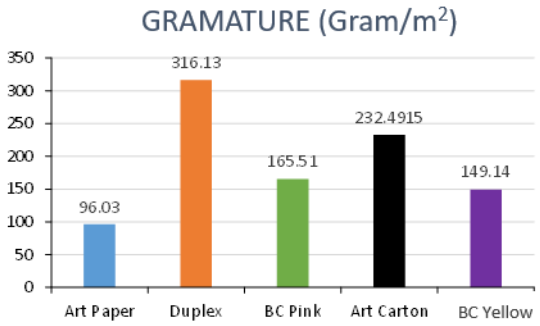

Fig. 1. The result test of gramature.

Figure 2 shows the measurement results for Art Paper, Duplex, BC Pink, Art Carton and BC Yellow, respectively (0.079; 0.37; 0.194; 0.212 and 0.065) mm with a variance of 3%, respectively; 1%; 1.3%, 4% and 2.76%. The highest thickness value is indicated by duplex paper while the lowest is yellow BC paper.

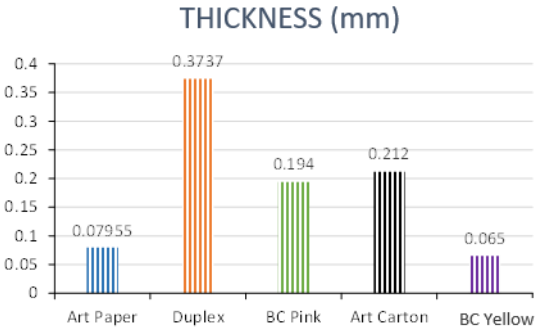

Fig. 2. The result test of thickness.

Water absorption (DSA) on paper was tested using the $Cobb_{60}$ method. $Cobb_{60}$ is the number of grams of water that can be absorbed by every 1 square meter in 60 seconds. This test is important to do to determine the sizing degree (degree of adhesion) in the paper. One of the functions of adhesives in paper is to increase the surface smoothness of the paper. This property is needed for printing paper, especially packaging so that the image looks brighter. The method of testing water absorption can also be done in a simple way, namely by dipping the test sample into a measuring cup and then measuring the absorption speed [10].

Figure 3 shows the results of the water absorption test for Art Paper, Duplex, BC Pink, Art Carton and BC Yellow which are calculated based on Equation (1), respectively (17.4; 13.37; 45.989 (Filt); 48.241 (Wire).); 19.22; 44.888 (Filt) and 47.214 (Wire)) gram/m^2. In BC paper, both BC Pink and BC Yellow, there are 2 sides of the paper, namely the Filt side (Smooth Side) and Wire (Coarse Side) therefore it is necessary to test the absorption capacity on both sides.

The results of the water absorption test show that Art Paper, Duplex and Art Carton meet the standard water absorption value for printing paper, which is a maximum of 30 grams/m^2.

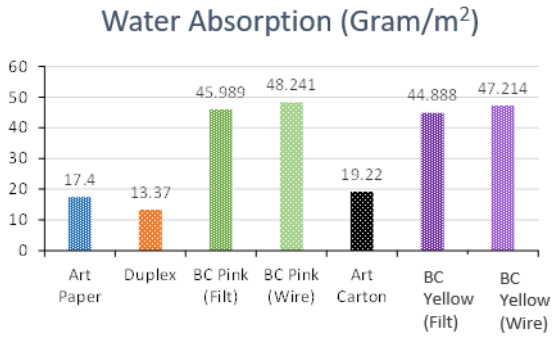

Fig. 3. The result test of water absorption.

Oil absorption (DSM) is a quantity that states the nature of the absorption of paper/cardboard to standard liquids. By dropping the test liquid on the surface of the paper at a certain speed, it will produce an oval-shaped print. The stronger the absorbency of the paper, the shorter the oval length. Oil absorption is calculated based on the reciprocal of the length of the printed liquid on the test line, expressed in units of 1000/mm, under standard conditions. Figure 4 shows the results of the oil absorption test for Art Paper, Duplex, BC Pink, Art Carton and BC Yellow paper.

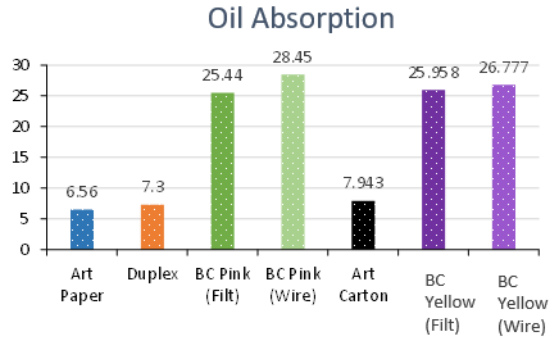

Fig. 4. The result test of oil absorption.

If the ink is printed on a paper surface that has many pores, the ink is absorbed by the paper more quickly. This means that more ink is used, the print dries quickly, the possibility of see-through and chalking occurs. Therefore, the value of oil absorption is limited to a maximum of 30 (SNI Printing Paper). From the test results on Art Paper, Duplex, BC Pink, Art Carton and BC Yellow paper, all of them meet printing paper standards.

Table 1. The Result of Resistance Test

No	Sample Paper	Side	Direction	Resistance test (m poise/detik)
1	Art Paper	FW	CD	Good
			MD	Good
2	Duplex	FW	CD	448
			MD	378
3	BC Pink	F	CD	Good
			MD	Good
		W	CD	Good
			MD	Good
4	Art Carton	FW	CD	Good
			MD	Good
5	BC Yellow	F	CD	Good
			MD	Good
		W	CD	Good
			MD	Good

The surface pullout resistance is the strength or weakness of the paper surface due to the printing force using the IGT printing test tool, which is calculated as the product of the viscosity of the ink with the print speed expressed in meters poise per second. In this study, the pullout resistance value was calculated using Equation (2). Table 1 shows the pullout resistance test results for Art Paper, Duplex, BC Pink, Art Carton and BC Yellow paper. The plucking of fibers during printing is a common problem. This is because of the printing force, the ink is too sticky or thick and the problem of moisture in the print chamber, so that the water content in the paper increases. The increase in water content will cause the tensile strength of the sheet of paper to be weak, resulting in fiber removal which results in reduced print quality (white spots).

Furthermore, the paper's chemical properties were tested, namely the degree of acidity (pH) test. The acidity of the paper is the concentration of hydrogen ions with the paper extract solution. Low acidity on paper will cause prints to dry for a long time, resulting in print transmission, faded print colors, thus affecting the quality of print production, especially for packaging printing [11]. The results of the paper pH test are shown in Table 2. In Table 2 shows that the pH meets the criteria for printing paper. The minimum pH criterion for printing paper is 4.9.

Table 2. The Result of pH test

No	Sample Paper	pH
1	Art Paper	6
2	Duplex	6
3	BC Pink	6
4	Art Carton	6
5	BC Yellow	5

Brightness or whiteness test is carried out to test the optical properties of the paper. Prints that contrast between the image and the paper surface make the quality of the prints better, but to read the printouts over time the eyes become tired. Therefore, the brightness value for printing paper with more text than images needs to be limited. Like for example if we want to print the composition on the product packaging.

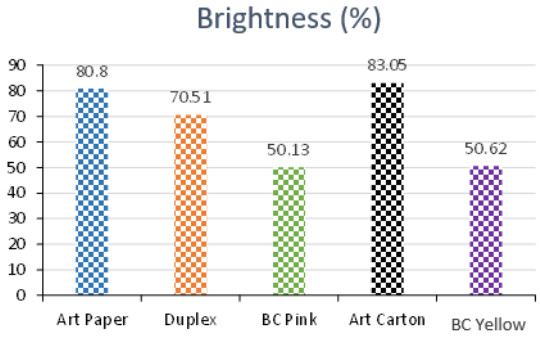

Fig. 5. The result test of brightness.

The results of the white degree test on Art Paper, Duplex, BC Pink, Art Carton and BC Yellow papers are shown in Figure 5, the values are 80.8%, respectively; 70.51%; 50.13%; 83.05% and 50.62%. The requirements for printing paper according to SNI are those that meet the white degree value, which is 65-75%. The test results show that those that meet the requirements for printing paper are Art Paper, Duplex and Art Carton.

Finally, the mechanical properties of paper were tested, namely tensile resistance and tensile strength. Measurement of tensile strength of a material can be calculated based on the maximum stress (stress) that a material can withstand when stretched or stretched, before the material breaks. Stress is the term used when the applied force is expressed relative to the cross-sectional area [12].

There are two types of fiber directions, namely MD (Machine Direction) which is the direction of the paper fibers parallel to the direction of the paper travel path along the paper machine,

while CD (Cross Direction) is the direction of the paper fibers perpendicular to the MD. In this tensile strength measurement the paper is tested in 2 directions, namely CD and MD.

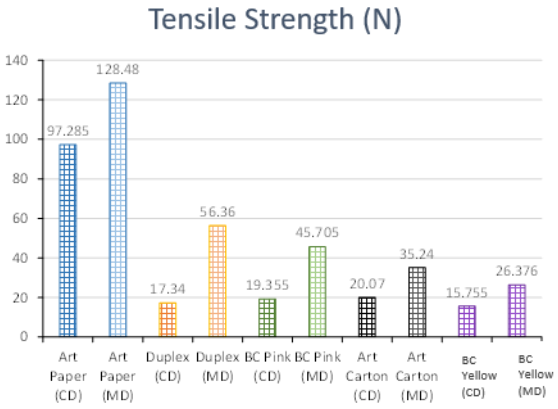

Fig. 6. The result test of tensile.

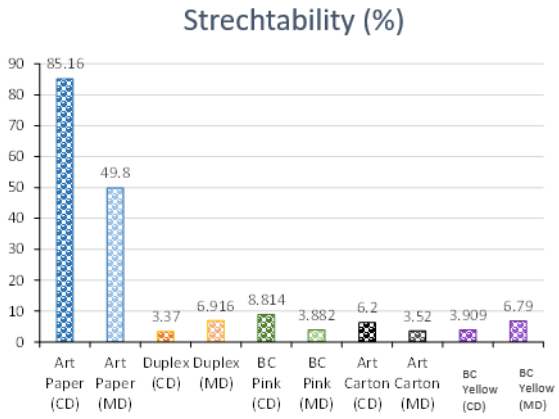

Fig. 7. The result test of strechtability.

Figure 6 shows the results of the tensile strength test and Figure 7 shows the results of the tensile strength test. The difference in the tensile strength of the papers studied is due to the difference in the length of the fibers that compose the paper [13]. Casey (1981) [14] reported that the tensile strength of paper is proportional to the square of the root mean of the ratio of fiber length to weight. This difference in tensile strength is also due to the influence of different paper-making methods.

Vivi in Nurminah (2002) [13] has investigated the effect of the method of manufacture and composition of the type of pulp on the increase in tensile index in the manufacture of oil-resistant paper. Vivi found an increase in the tensile index in the surface sizing method (a method of filling the surface of a sheet of paper, usually with starch). The benefits of surface

sizing of packaging paper include oil penetration resistance and increased tensile resistance. Paper is generally composed of cellulose fibers. In the paper production process, the fibers will follow the direction of the machine or often called MD (machine direction). In this MD, the fibers are arranged according to the machine direction.

The value of tensile strength for MD is different from that of TD/CD (transverse direction/cross machine direction) or across the machine direction [15]. The tensile strength value on MD is higher than the tensile strength on CD. This can be caused because in MD the fibers are arranged regularly and collected in one direction of pull so that the force required to break the paper is greater. Whereas in CD the fibers are transverse to the direction of pull, so the strength between the fibers is not too strong when pulled.

4. Conclusion

Based on the test results of grammage, thickness, water absorption, oil absorption, pulling resistance, pH, brightness, tensile resistance and stretchability, the physical, chemical, optical and mechanical properties of paper are obtained. The results of the grammage and thickness measurements showed that the highest was duplex paper. In testing the water absorption, oil absorption and pH of all papers, all paper meets the standards for printing paper. In the endurance test, all paper is in good condition except for duplex paper. In the brightness test, only Art Paper, Duplex and Cardboard meet the standards for printing paper. Based on the results of testing several types of paper, the authors suggest that the most suitable paper for packaging materials is Art Carton paper with grammage specifications that are not too thick (0.212 mm) and heavy (232.49 gr/m^2). DSA and DSM values also meet printing paper standards so as to produce clearer images when used in packaging printing. The pullout resistance value also shows good. In addition, the pH value of Art Carton is also not too acidic so that the prints dry faster and finally the brightness value shows the highest, which is 83.05% so as to make the print quality better.

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