WATER VAPOR PERMEABILITY (WVTR) OF PACKAGING CARTONS IN EXTREME HOT AND HUMID ENVIRONMENTS

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ABSTRACT

The paperboard packages must protect and store the product. The air and moisture permeability of the packages which are in direct contact with the foodstuff are particularly important. Therefore, in the study; In order to determine the moisture permeability, the paperboards used had different thicknesses (24,26,28 micron) and grammages but, the same properties (inner structure, surface and coating). Paperboards were subjected to WVTR test for 7 days at 22°C temperature, 55% humidity and 42°C temperature, 85%humidity values using Thwing-Albert EZ-Cup Vapometer Permeability Cups. Reactions of paperboards against standard and extreme humidity and temperature conditions were determined.

Keywords: WVTR, paperboards, humidity, water vapor permeability

Introduction

Paper products made of cellulose fiber have been widely used as packaging materials, due to their favorable properties such as biodegradability, sustainability and low environmental impact. [1] But, the hydrophilic properties of the cellulose fiber create a low water vapor barrier property of the paper-based packaging materials, is not sufficient to meet the requirements for high-barrier applications or extended application in packaging [2]. The water vapor permeability values are largely dependent on the coating material [3]. Using various types of barrier layers in the packaging industry, for example, laminated plastic or metal foil etc., the water vapor barrier property of the packaging cartons has been increased. However, in terms of recycling, the dispersion coating is considered to be an environmentally friendly alternative [4].

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The packaging material plays an important role for food safety and quality preservation. It should provide control of mass transfer between the food, the packaging material itself and the environment. [5] The package must provide adequate protection against rapid temperature and moisture changing [6]. However, sometimes we use packages without any protection layer direct contact with the product. This means that the product must be well protected from heat and moisture.

Temperature and humidity are very important for both the food industry and the cardboard packaging industry. Direct food contact packaging which placed for the exhibit and store location should be selected carefully. Especially, countries in tropical regions where have high temperature and humidity, the resistance of the paperboard package against moisture becomes even more important. Some cities that have high temperature and humidity conditions are given in Table 1 below.

Table 1. Some of cities which have high humidity [7]

Country	City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
BRAZIL	Barcelos	87.0	86.0	88.0	90.0	91.0	91.0	88.0	88.0	88.0	88.0	87.0	87.0	88.2 %
CANADA	Cape St James	86	85	84	84	86	89	91	90	88	87	85	85	86.7 %
HONG KONG	Hong Kong	83.0	88.0	90.0	92.0	91.0	91.0	89.0	91.0	88.0	83.0	81.0	80.0	87.2 %
INDIA	Cherrapunjı	70.0	69.0	70.0	82.0	86.0	92.0	95.0	92.0	90.0	81.0	73.0	72.0	81.0 %
ITALY	Cısa Pass	81	86	81	85	83	85	81	83	86	89	88	87	84.6 %
NETHERLANDS	Eelde	97.0	96.0	96.0	96.0	95.0	96.0	97.0	97.0	97.0	97.0	97.0	97.0	96.5 %
VENEZUELA	Tumeremo	86.0	84.0	80.0	80.0	85.0	89.0	88.0	86.0	83.0	82.0	85.0	88.0	84.7 %

Experimental part

In this study, the paperboards multi-layer used had different thicknesses (24,26,28 micron) and grammages but, the same properties. Their top surfaces are coated and back sides are uncoated. All paperboard samples were conditioned at 22°C temperature, 55% relative humidity (RH) and 42°C temperature, 85% relative humidity (RH) in the Caron 6030 conditioning chamber according to TAPPI T464 and T448 standards using Thwing-Albert, 68-3000 Vapometer EZ-Cups (figure 1). Before starting the test, weight of all cardboards and CaCl2 were weighed and placed in the containers. Then Thwing-Albert, 68-3000 Vapometer EZ-Cups were prepared, weighted, and placed into the conditioning chamber. Each sample was weighted and recorded during 7 days, in the frequency of every 24 hours. In the final measurement, the total weight of the EZ-Cups, paperboard weight and the amount of water vapor obtained by CaCl2 were determined. The results of the measurements are given in tables and graphs in results section.



Figure 1. Thwing-Albert, 68-3000 Vapometer EZ-Cups

Results and Discussion

According to the WVTR test results were performed seven days, it was determined that the water vapor permeability of the paperboard of different thicknesses were showed different behavior in standard (22°C - 55% RH) and extreme (42°C - 85% RH) environments. The results are shown in the graphs and pictures below.

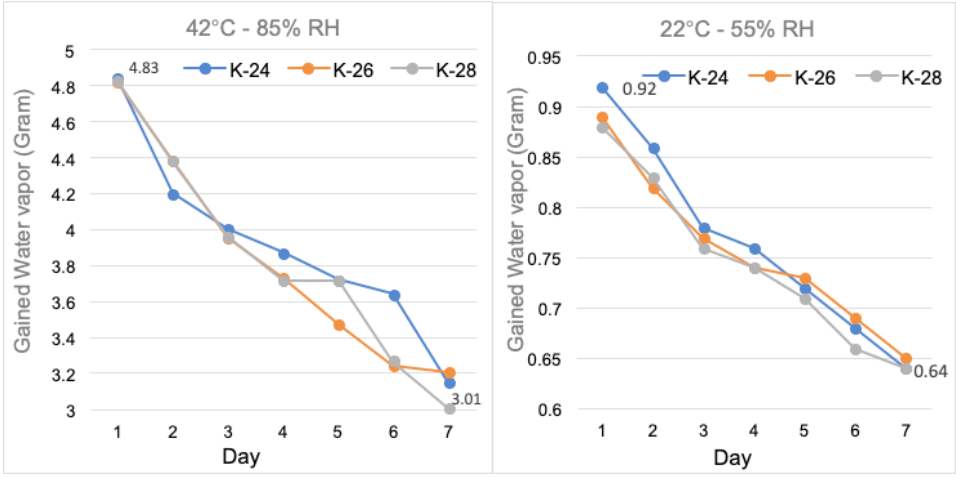

Figure 2. The amount of water vapor that paperboards took for 7 days.

Figure 2 shows that the paperboards got more water vapor in high temperature and humidity values, but gained water vapor amount continued to decrease for both conditions during 7 days.

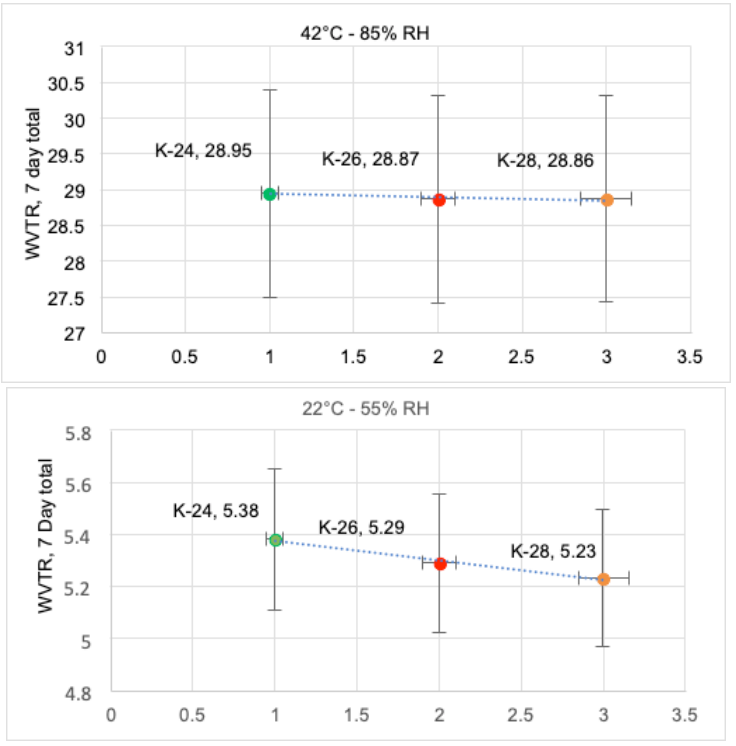

Figure 3. Total water vapor amounts for 7 days.

When the total amount of water vapor taken for 7 days is compared, it is determined that the paperboards in extremely hot and humid environment absorbed 5 times as much as the paperboards in the standard humidity environment. This situation is particularly problematic for food contact with paperboard boxes such as pasta and cereals. All results are very close to each other with a 5% error margin. This showed that cardboard thicknesses do not have too much effect on moisture permeability.

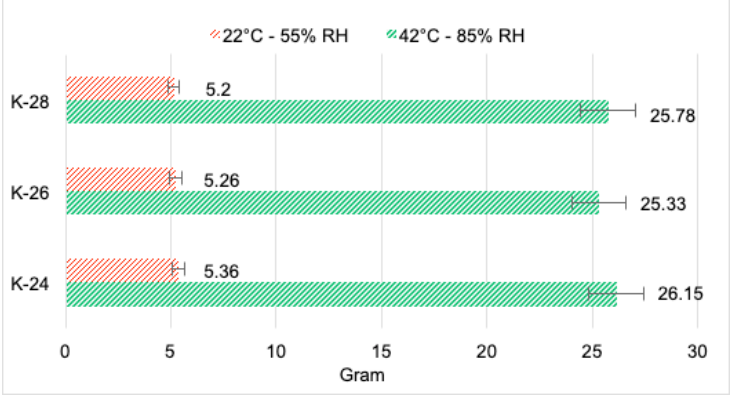

Figure 4. The gained water vapor amount of desiccant (CaCl2)

When the total amount of moisture taken by desiccant (CaCl2) is examined, it is determined that the amount of moisture is very high in high temperature and humidity conditions.

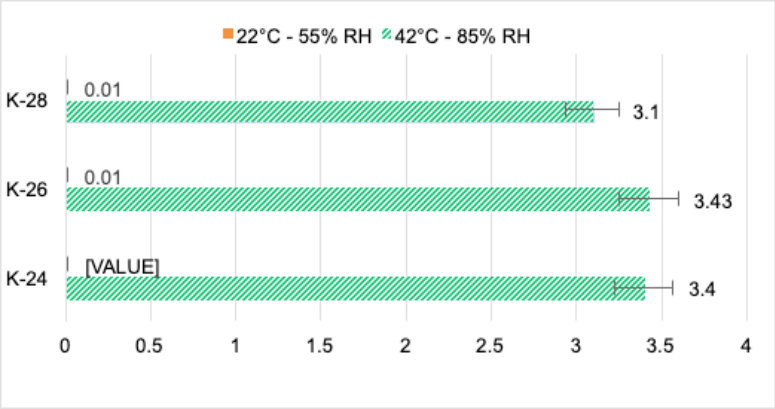

Figure 5. The gained water vapor amount of paperboards

When the moistures of the paperboard thickness are compared, there is no noticeable difference in standard (22°C - 55% RH) humidity and temperature values. However, the paperboards absorbed too much moisture at high temperature and humidity (42°C - 85% RH) conditions. Bursts on the surface some of the paperboards can be seen in the figure 6.

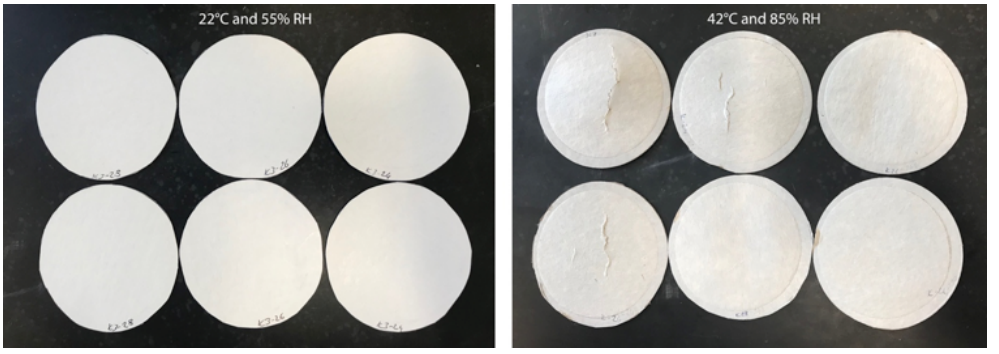

Figure 6. The pictures of paperboards after 7 days

Conclusion

Studies have shown that, paperboards have absorbed some moisture into their structure in the hot and humid environment. This can be said also for standard conditions (22°C-%55 RH). But there are some differences between the amount of moisture they absorb.

Cracking and bursting occurred on the paperboards surface due to the fact that they absorbed more moisture after waiting a certain period of time in the extremely hot and humid environment. This showed that the amount of excess moisture in the environment has affected the structure of the paperboards. They cannot protect the product within the paperboard box because the product has direct contact with the box surface. This creates a big risk for the

food packaging industry and human health. Packages that are used in extreme hot and humid conditions must have barrier properties against these climate types.

It was also determined that paperboard thicknesses did not have much effect on water vapor permeability.

References

[1] Zhaoping Song, Huining Xiao, Yi Zhao, Hydrophobic-modified nano-cellulose fiber/PLA biodegradable composites for lowering water vapor transmission rate (WVTR) of paper, Carbohydrate Polymers, Volume 111, 13 October 2014, Pages 442-448

[2] Pan Y., Xiao, H., Song, Z. "Hydrophobic modification of cellulose fibres by cationic-modified polyacrylate latex with core-shell structure" Cellulose, Volume 20, Issue 1, 2013, Pages 485-494]

[3] J. Agric. Food Chem. 1998, 46, 4056−4059 Enzymatic Hydrolysis of Zein-Wax-Coated Paper

[4] Roger Bollström, Jarkko J Saarinen, Jukka Räty and Martti Toivakka, Measuring solvent barrier properties of paper Measurement Science and Technology, Published 5 December 2011 • 2012 IOP Publishing Ltd. Measurement Science and Technology, Vol. 23, Number 1

[5] Galina Rodionova, Marianne Lenes, Øyvind Eriksen, Øyvind Gregersen, Surface chemical modification of microfibrillated cellulose: improvement of barrier properties for packaging applications, Cellulose (2011) 18: 127. https://doi.org/10.1007/s10570-010-9474-y

[6] Patrizia Fava, Luciano Piergiovanni and Ella Pagliarini, Design a Functional Box for Take-away Pizza, PACKAGING TECHNOLOGY AND SCIENCE, Packag. Technol. Sci. 12, 57±65 (1999)

[7] http://data.un.org/Data.aspx?d=CLINO&f=ElementCode%3A11 10.09.2018