THE EFFECTS OF ECOLOGICAL PROPERTIES ON THE ASSESSMENT OF PAPERBOARD PROPERTIES FOR PACKAGING

Josip Bota, Maja Brozović, Dorotea Kovačević, Jurica Dolić

Faculty of Graphic Arts University of Zagreb, Department of Graphic Design and Imaging, Getaldićeva 2, Zagreb, Croatia

Abstract

It is known that consumers choose product based on packaging and its design, but the type of paperboard used is also one of the important factors that can improve visual impressions. This study investigates how consumers perceive packaging paperboard in relation with its composition and how they link paperboards with different types of products. Recycled and non-recycled paperboards were characterized by testing optical and mechanical properties. The same samples were given to participants to assess the price, quality and sustainability of the material and to link the samples to different product types. It was found that even though there is a small difference in optical properties the consumers can easily spot the difference. Also, the study presents how the participants assessed the use of recycled and non-recycled paperboards in correlation with different product types (food, pharmaceuticals, tobacco, cosmetics and hygienic products)

Keywords: Recycled paperboard, packaging, ecological properties, consumer perception
1. INTRODUCTION

In recent years paperboard and cardboard production are in constant rise. Statistical data indicates a constant increase in production of paper and cardboard (see Figure 1). The rise of demand is mostly because of the global increase of packaging production. Almost half (40-50%) of cellulose material waste is acquired from packaging [1]. On April 4th 2016 Transparent Market Research announced that the cardboard and paperboard industry is worth $ 122.69 billion, and by 2024 it is projected to be worth $ 227.47 billion [2]. In 2009 Smithers Pira's 2010 report states that 38% of the packaging industry was oriented towards cellulose material [3] and a report from 2014 stated that 42% of luxury packaging were made from paperboards and cardboard [4]. Paperboard packaging is one of the most widely used on the market. Its life-span can be from one day to multiple months or even years. Function of packaging is to protect the product from mechanical damage and decay, safe transportation and distribution, to inform customers and to promote the product through design activity [5]. In order to achieve these goals packaging material needs to meet a wide range of physical, mechanical and optical properties. It should be resistant to temperature oscillations, adapted for print and coatings, resistant to wear and tear and yet suitable for moulding, with an addition of meeting high aesthetic standards [6].

Fig 1: Production volume of paper and cardboard worldwide 2006 to 2015

(in million metric tons) [7]

Today's packaging materials meet most of the requirements. Economic and environmental needs constantly emphasize the necessity to improve and find more efficient and cost-effective packaging materials. There is a constant comparison of recycled and pure cellulose as a packaging material. Recycled cellulose materials are economically viable and environmentally friendly. Paperboards with pure cellulose have a high percentage of primary fibres and the purity of the composition enables better printing properties and excellent features for embossed printing and structural design. The European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste has a goal on minimizing the effect of packaging and
One study in New Zealand showed that in conditions of high relative humidity conditions, paperboards with pure cellulose showed better mechanical properties than recycled. In all samples, the non-recycled cardboard had higher compression strength [8]. It is known that the mechanical strength of recycled cellulose material decreases after the first recycle and even more after the second, so sorting of paperboard can also lead to recycled paperboards with better properties [9].

The aim of this paper is to characterise tested paperboard samples and to determine consumer preferences towards recycled and non-recycled packaging material according to their quality, price and sustainability.

Recycled and non-recycled paperboards are independent variables and quality, price and sustainability are dependent variables.

1.1. **Hypotheses:**

H1 - Non-recycled paperboard leaves an impression of higher quality.

H2 - Non-recycled paperboard leaves an impression of higher cost.

H3 - Recycled paperboard is perceived as more sustainable than non-recycled paperboard.

H4 - Consumers link recycled and non-recycled with certain types of product.

2. **METHODOLOGY**

2.1. **Materials**

Two types of paperboard were used in the study. Umka color® 280 g/m² GD2 paperboard with a high percentage of recycled/secondary fibres and a GC2 paperboard Allyking® 270 g/m² made from virgin mechanical pulp.

2.2. **Methods**

*Optical and mechanical properties*

The paperboard samples were first characterized to confirm the difference in optical and mechanical properties. The Technidyne Color Touch 2® spectrophotometer was used to determine the surface colour and brightness of the paperboard. Dimensions of the tested paperboard samples were 50 x 50 mm. The instrument and the number of test samples are in compliance with the ISO optical and CIE Lab standards [10,11]. Mechanical properties of the samples were defined calculating their Bursting Index (x) as one of the
most important properties of paperboard. It was measured using Lorentzen & Wettre Bursting Strength Tester (ISO 2758:2001). Dimensions of the tested paperboard specimen were d=100 mm, measuring range d=50 mm, and the device diaphragm had a diameter d=33,1 mm. The number of samples is determined according to ISO 2758:2001. The index was calculated using the formula:

\[ x = \frac{p}{g} \]

- \( x \) - bursting index (kPa \cdot m^2/g)
- \( p \) - bursting strength (kPa)
- \( g \) - paper grammage (g/cm²)

**Interview**

A structured interview was chosen for data collection because it was necessary for the participants to see and feel the prepared paperboard samples. 30 people participated in the study.

There were two paperboard samples cut to the 6 cm x 10 cm dimension. The size of the samples was chosen to simulate the dimension of common packaging size. The samples were divided into two groups according to degree of recyclable material: recycled and non-recycled.

At the beginning of the interview the paperboard samples were given to participants with no explanations. They were allowed to touch and observe the samples but they were not allowed to turn them over so they would assume what type of paperboard was used for the sample production. Then the participants evaluated the sample using a 5 point scale (1 was the lowest and 5 the highest grade) according to tested product characteristics: price, quality and sustainability of products packaged in that type of paperboard.

After the evaluation task, the participants were asked to link a list of product types with the paperboard samples. In this task, they could assign more samples to certain product type or none.

3. **RESULTS AND DISCUSSION**

3.1. **Characterization**

As expected characterisations of the paperboard optical properties (Table 1) showed that recycled paperboards have lower lightness values than non-recycled. This is common for recycled paperboards due to the multiple layers of recycled cellulose below the top layer. The positive CIE \( b \) values of non-recycled paperboard indicate that the tint shift is in the orange hue while recycled paperboard has a blue tint. The blue coloration is usually used to compensate the grey-ish tint that emerges from the lower recycled layers.

**Tab 1: CIE Lab values of front and back sides of recycled and non-recycled paperboard**

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>a</th>
<th>b</th>
<th>tint</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycled (GD2)</td>
<td>91,94</td>
<td>0,22</td>
<td>-2,77</td>
<td>1,18</td>
</tr>
<tr>
<td>non-recycled (GC2)</td>
<td>93,31</td>
<td>0,04</td>
<td>1,89</td>
<td>-1,13</td>
</tr>
</tbody>
</table>
Table 2 presents that ISO brightness measurements of recycled and non-recycled paperboard show some slight difference in value. Brightness is the percentage of white as a direct reflection, measured in the blue range of the visible spectrum and has an impact on readability and colour intensity so it is important for producers to get similar effects no matter the paperboard used.

**Tab 2: ISO brightness of recycled and non-recycled paperboard**

<table>
<thead>
<tr>
<th></th>
<th>ISO brightness ©</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycled (GD2)</td>
<td>81,34</td>
</tr>
<tr>
<td>non-recycled (GC2)</td>
<td>81,42</td>
</tr>
</tbody>
</table>

The mechanical properties were tested defining the bursting index of paperboard samples. This method is the most representative because it stresses the sample using multiple forces simultaneously and is not affected by paper grammage. The results show (Table 3) expected difference between recycled and non-recycled paperboard because recycled paperboards have shorter cellulose fibres which significantly affect the mechanical properties [12].

**Tab 3: Burst strength of recycled and non-recycled paperboard**

<table>
<thead>
<tr>
<th></th>
<th>Burst index (kPa⋅m²/g)</th>
<th>max</th>
<th>min</th>
<th>st. dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycled (GD2)</td>
<td>1,21</td>
<td>1,33</td>
<td>0,98</td>
<td>0,09</td>
</tr>
<tr>
<td>non-recycled (GC2)</td>
<td>1,89</td>
<td>2,1</td>
<td>1,7</td>
<td>0,12</td>
</tr>
</tbody>
</table>

3.2.  Interview

The results of the assessment (Table 4) showed that participants assessed the products in the non-recycled paperboard as more expensive while linking the recycled paperboard with cheaper products. Similar results were obtained in the assessment of quality. From the obtained results we can assume that attributes of price and quality are linked. As expected the recyclable paperboard was graded as more sustainable.

**Tab 4: Assessments of price, quality and sustainability of paperboards (mean grade)**

<table>
<thead>
<tr>
<th></th>
<th>price</th>
<th>quality</th>
<th>sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycled (GD2)</td>
<td>1.5</td>
<td>1.3</td>
<td>4.1</td>
</tr>
<tr>
<td>non-recycled (GC2)</td>
<td>4.2</td>
<td>4.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Even though the characterisation measurements did not show big difference in CIE Lab values and ISO brightness these results show that human perception can identify the difference. But it should be taken into account that there is also a difference in surface texture of GC2 and GD2 paperboard which can also contribute in in quality assessment. It is also important to note that research found that consumer will accept paper with a wider range of colour tint if they are aware that the paper is being recycled [13].
From the results of assigning product type (Figure 2) to the type of paperboard sample it is shown that most recyclable paperboard is mostly linked to food produce, a little less with tobacco and hygienic products. Non-recycled samples are mostly connected with cosmetics and pharmaceuticals (food supplements included). The results showed that customers are more inclined to connect non-recycled paperboards with high-end products (higher quality and price range). Recycled paperboards are considered to be more sustainable with lower quality and price. This confirms the first three hypotheses.

The participants are more prone to link food, tobacco and hygienic products with recycled paperboard while relating pharmaceutical and cosmetic products with recycled paperboards. This is an interesting result because tobacco packaging mostly uses paperboards made from virgin cellulose. This lapse in assessment should be investigated more in depth to reveal its connection with recycled paperboard. One explanation can be that consumers perceive tobacco as a natural product, so they connect it with sustainable paperboards.

These findings can help producers to choose materials according to what they want to communicate. It is important to note that materials are not only used for communication or because of their economic factors. Some products, like food and pharmaceutical products need to use non-recycled paperboard to decrease the possibility of contamination.

Also, recycled paper is used in the industry for a longer time and because of that consumers perceive it as a lower functional risk (low probability of bad performance, low cost, and no risk of physical harm to the purchaser or user) [14], so producers should not hesitate to use recyclable materials whenever possible. Further research should try to establish causative factors of why certain paperboards have different impressions on consumers. This would help understand are their assessments based on experience, knowledge or first impressions.
4. CONCLUSION

The characterisation of the paperboard samples showed a small degree of difference in the optical properties of recycled and non-recycled paperboard while a much more notable difference was observed in the mechanical properties.

Through the interview a link was found between the degree of recycled cellulose material in the paperboard and the assessment of product price. If the paperboard of the packaging has pure cellulose fibre the product is perceived as more expensive. The results indicate that when a product is packed in a paperboard with a higher degree of recycled cellulose fibre it is perceived as more sustainable. An unexpected finding showed that the participants assessed that tobacco products are packaged mostly in recycled paperboard.

REFERENCES