THE EFFECT OF BEATING ON THE DYEING OF CELLULOSE

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Abstract: *Dyes and pigments are important colorants used in dyeing of paper, cardboard, fabric, food, plastic, wood materials. The dyes and pigments used for this are very diverse and have a wide range.*
With the increasing in demand for dyed paper day by day, the development of new technologies has become necessary. Since the natural colour of the paper is not much of a concern, the papers have been started to be dyed in different shapes to obtain products with shades ranging from bright pastel to dark and saturated tones. Tone and density can be adjusted according to need and requests. Colouring in paper is usually coloured by adding pigments or dyes to the pulp during pre-production preparation. Almost 95% of dyed papers are prepared in this way. For this purpose, direct acidic and basic dyes are used.
The effectiveness used pigment or dye varies depending on the raw material and the environmental conditions. The purpose of this study, beating and pH is to improve the effect on cellulosic dyeing and paper properties. For this, two different types of pulp were selected as bleached softwood kraft pulp (BSWP) and bleached hardwood kraft pulp (BHWP). The dyeing process was carried out using four different colours in the beaten and the unbeaten pulp (60minute with Valley's beater). They produced sheets from the dyed pulp. It was made colour measurements on the produced sheets and compared obtained values. The results will help to give an idea of the effectiveness of coloured inks used during printing on coloured paper.

Key words: dye, pigments, beating, kraft pulp

1. INTRODUCTION

Wood fibers are divided into two groups as softwood and hardwood. Hardwood is from deciduous trees such as birch, eucalyptus and poplar. Hardwood fibers, for example European birch, are usually 1-1.5 mm long and 16-22 µm in diameter. Softwood is from coniferous trees such as spruce and pine. Softwood fibers on the other hand, for example European spruce or pine, are 2.5-3.6 mm long and 24-59 µm in diameter (Daniel, 2009; Karlsson, 2006).
By Casey; "Any type of fiber used in paper making can be painted, but they take different colours. The difference in the characteristics of the fibers according to the tree type is effective in this. Hardwood pulp fibers are more round and bulky than softwood fiber. They have a larger surface area than a similar weight of softwood fiber. Since in dyeing paper the surface of the fiber is dyed, the same amount of dye used on a hardwood pulp will produce a lighter shade than on softwood furnish. In a mixed furnish containing a blend of both types of fiber, the shade will be lighter if the proportion of hardwood pulp is increased" (Casey, 1980).
Nowadays new technologies have been developed for painted paper. Because the natural colour of the paper is not very popular, the paper has started to be painted in different ways to produce products with shades ranging from glossy pastels to dark colours to saturated shades. Tone and density can be adjusted according to needs and requirements.
The papers are usually coloured by adding a colorant to the paper stock in the preparation stage. Nearly 95% of the dyed papers are prepared in this way. For this purpose, direct acidic and basic dyes are used. Since the paint penetrates all the fibers of the paper, the most efficient treatment is the dyeing of the substances (Drzewińska, 2008).
Beating or refining is one of the most important process in paper making.. It not only controls the properties of the finished sheet, as mentioned Often the effect of beating on strength (e.g. tensile, elastic modulus, Scott-Bond) is explained simply by increased inter fibre bonding. Most frequently it is assumed that bonding improves because beating increases fibre flexibility. Runnability increases cellulose of beating. It also affects the mechanical properties and structure of the paper (Hiltunen, 2003; Casey, 1980).
Beating process brings changes to the structure and properties of fibers, such as fiber swelling, fiber shortening, internal and external fibrillation, etc. Chemical pulp fibres swell as a result of beating. Fibre swelling is often called internal fibrillation (Lecourt, Sigoillot & Petit-Conil, 2010).

Writing and printing papers are usually produced from bleached chemical softwood or hardwood pulps. The quantity of these pulps and their brightness have an impact on the final optical properties of the paper produced.

2. MATERIAL AND METODS

Bleached softwood and hardwood kraft pulp were used for this study. Both pulp are supplied from a commercial paper mill. Bleached hardwood and softwood pulp in proportion 1:1, with beating degree 40°SR (Schopper Riegler). Pulp beating was carried out on laboratory scale in a Valley's beater according to Standard PN-ISO 5264-1:1999. Four-color dye was used to stain pulp. Paper was prepared from the dyed pulp in two different weights. The dyes were added to a 1,5 % pulp suspension at a temperature of 20 °C, with a pH of approx. 8. The contact time of dyeing substances with the pulp amounted to 30 minutes. Dyed sample papers were produced as handmade paper on a British paper machine (Figure 1, 2 and 3)

Figure 1: British type hand paper machine

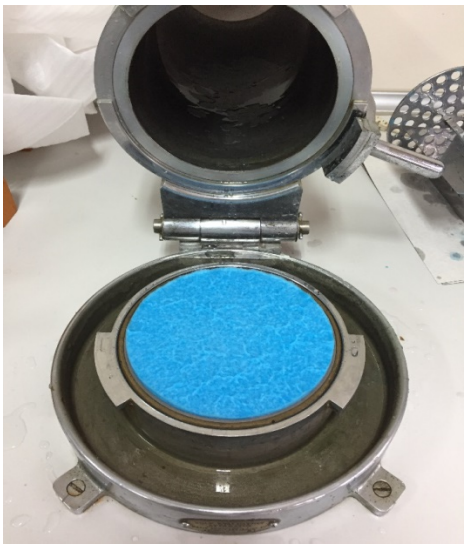

Figure 2: British type hand paper machine and painted paper sheet

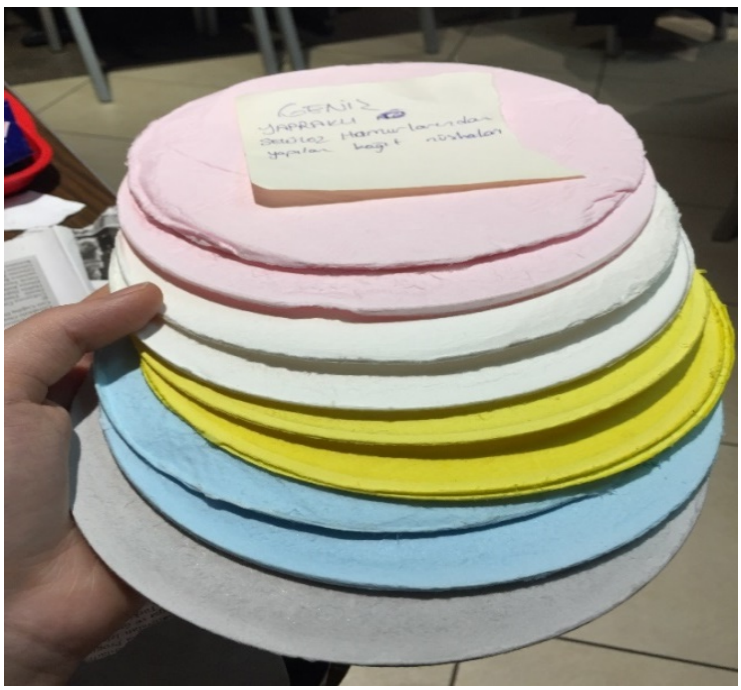

Figure 3: Samples of paper painted in different colours

2.1 The Determination of Coloured Papers Properties

The thickness of the coated recycled paperboard samples were measured using a TMI Micrometer. Air permanence was measured used an L&W Air Permeance Tester (Tappi T 460 om – 88) and roughness was measured using a L&W Bendtsen Tester (Tappi T 479 om – 91). L*, a*, b* colour values of the coloured and white papers were measured using X-Rite eXact Densitometer. It was used A BYK Gloss Meter for determining gloss values of the printed samples and the coloured and white papers as ISO 2813 (Sonmez, 2017).

3. RESULTS AND DISCUSSION

Thickness, grammage, Porosity and Roughness are among the most important structural properties of paper that characterise for general description. The Physical properties of high grammage and Low grammage coloured papers are given in In Table 1 and Table 2. Roughness value of Low grammage coloured papers is lower than Low grammage coloured papers. Its means Low grammage coloured papers is smoother. But, they have more air permeability than them due to their low air permeability and thickness.

Table 1: The Properties of High Grammage Coloured Papers using Cyan, Magenta, Yellow and Black

Ink	High grammage			
	Grammage (g/m^2)	Thickness (µm)	Porosity (ml/min)	Roughness (ml/min)
Cyan	54	1	85	275
Magenta	74	1	79,1	379
Yellow	69	1	73,4	466
Black	46	1	89,5	232

Table 2: The Properties of Low Grammage Coloured Papers using Cyan, Magenta, Yellow and Black

Ink	Low grammage			
	Grammage (g/m^2)	Thickness (µm)	Porosity (ml/min)	Roughness (ml/min)
Cyan	36	0,5	178	186
Magenta	29	0,5	189	180
Yellow	32	0,5	279	196
Black	32	0,5	214	220

In Figure 4, the L* values of the coloured and white papers are given depending on the grammage change. Figure 4 showed that lightness values of the low grammage-coloured papers was higher than the high grammage-coloured papers.

While, compared the lightness value of the white paper, the use of Cyan, Magenta and Black inks in the coloured-paper production was decreased the Lightness values, the use of Yellow inks had not effected significantly. Lightness is a major indicator for a good print (Sonmez & Oguz, 2017). Therefore, the higher the lightness, the lower the colour saturation. So, Yellow-coloured paper has lower colour saturation than other coloured paper.

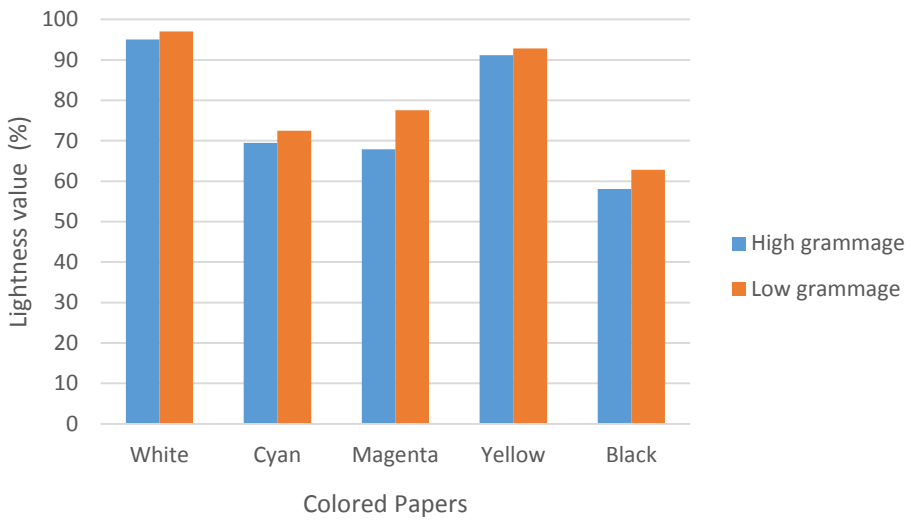

Figure 4: Lightness values of white paper and Coloured Papers using Cyan, Magenta, Yellow and Black

High chroma indicates high colour saturation, which is an important property for good quality paper, which including high colour gamut (Sonmez, 2011). Depending on the grammage change, the chroma values of the coloured and white papers are given in Figure 5. Having grammage of the coloured paper decreased, chrome values of all samples unlike Black were appear to be a noticeable reduced. These decrease were showed that colour gamut of the low grammage-coloured paper samples is the smaller than the low grammage-coloured paper samples. The higher chroma value was obtained in the high grammage-magenta-coloured paper.

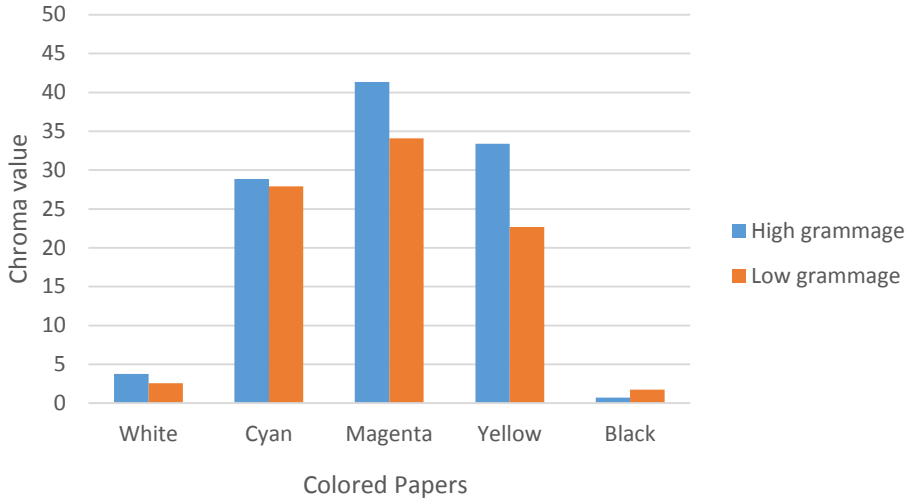

Figure 5: Chroma values of white paper and Coloured Papers using Cyan, Magenta, Yellow and Black

The gloss values of the all samples was measured at 60° and calculated Delta Gloss 60°. In, Figure 6, Calculated Delta Gloss 60° values were given depending on the grammage change. The grammage change decreased, the colored-papers produced using Magenta and Black inks were reduced the Delta Gloss 60° value. Conversely, the colored-papers produced using Cyan and Yellow inks were increased the Delta Gloss 60° value.

Generally, the coloration of the papers increased the gloss values. Increased the gloss was an important property the printability parameters, as the visual quality was advanced (Sonmez & Ozden, 2016).

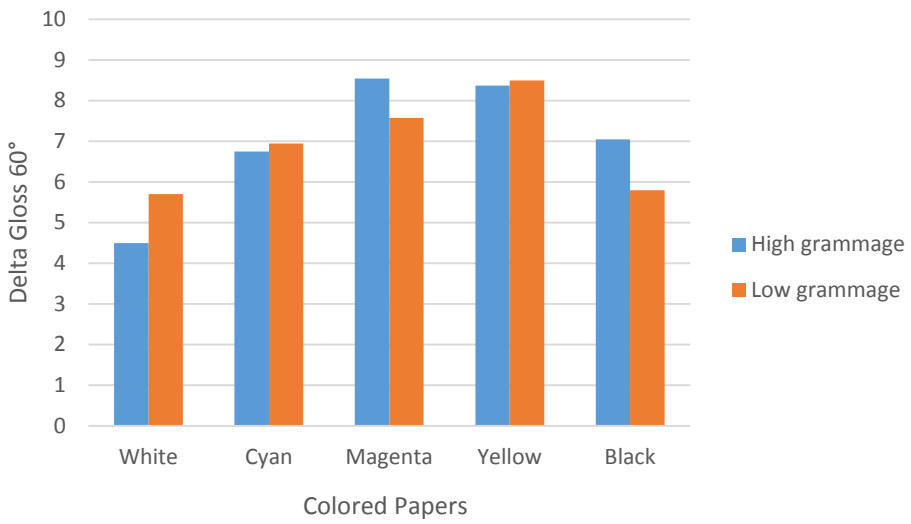

Figure 6: Delta Gloss 60° values of white paper and Coloured Papers using Cyan, Magenta, Yellow and Black

In Figure 7, the Delta E (⊿E) values of the coloured and white papers are given depending on the grammage change. Figure 7 showed that Delta E (⊿E) values of the low grammage-coloured papers was higher than the high grammage-coloured papers. This result shows that obtained different colour saturation in the Low and high grammage coloured papers.

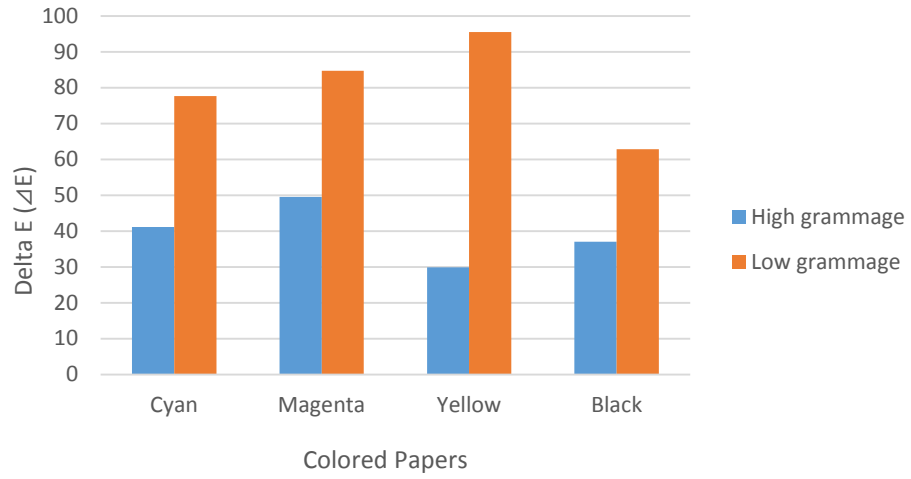

Figure 7: Delta E (⊿E) values of white paper and Coloured Papers using Cyan, Magenta, Yellow and Black

4. CONCLUSIONS

1. Lightness values of the low grammage-coloured papers was higher than the high grammage-coloured papers. Due to the fact that Yellow-coloured paper has high lightness, its colour saturation is lower than others coloured papers.
2. Grammage of the coloured paper decreased, chrome values of all samples unlike Black were appear to be a noticeable reduced. The higher chroma value was obtained in the high grammage-magenta-coloured paper. This show that the colour saturation value of the high grammage-magenta-coloured paper is high others coloured papers.
3. The coloured-papers produced using Cyan and Yellow inks were increased the Delta Gloss 60° value.
4. Delta E (⊿E) values of the low grammage-coloured papers and high grammage-coloured papers obtained different values. This result shows different colour saturation in the Low and high grammage coloured papers.

5. REFERENCES

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