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A Comparison of Color and Strength Properties of Various Paper Printed with Inkjet System Using Natural Inks

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Abstract

Printing with natural inks to the paper essential for various area like wrapping paper for foodstuff, paper cups etc. Therefore, the development of stable and commercial natural ink is gaining importance. The production methods and the surfaces chemicals (coating materials, fluorochemicals, sizing materials etc.) of the paper affect the color of the natural inks, which applied paper surface. The aim of this study is to evaluate the effect of natural inks on various paper types. Ink samples are cyan, magenta, yellow, black colors prepared to have the closest color properties to the commercial inkjet printing inks in the market. Yellow *Curcuma longa* extract, red *Rosa canina* extract, cyan *Indigofera tinctoria* extract, black *Alkanna tinctora* extract selected to prepare natural ink. The differences between the commercial ink and the natural ink applied paper samples CIE L* a* b* color values were evaluated. The application made with a commercial inkjet printer. Then strength properties of paper samples evaluated and compared. According to results, bleached white chemical paper color results were closest to commercial ink.

Keywords: Natural printing ink, paper color.

1. Introduction

The utilization of natural dyes derived from plant sources dates back to historical times. However, after the discovery of synthetic dyes, natural materials could not afford mass-scale industrial production rates and began to be reduced. As a result, most of the pigments and dyes are produced by synthetic compounds until recently [1]. However, environmental regulations have limited some of the synthetic materials in the industry and natural dyes, pigments and inks have gaining importance nowadays.

Recent development of natural digital printing inks leads to the development of biodegradable, non-toxic, environmentally friendly products. Besides, in a recycle process of the paper, natural inks are providing a cleaner ink removal system. Natural organic printing ink and paints are gaining popularity, especially for papers in contact with foodstuff [2]. It is expected to increase the demand for this kind of product [3].

Digital printing systems and conventional printing systems such as offset, gravure, flexo take their place in the printing industry in terms of both printing speed and personalized printing [4]. The rapid development of digital printing technologies allows the use of natural printing inks for trade.

Printing inks from natural substances that obtained renewable resources have some advantages. Compared the synthetic inks, natural inks do not lead environmental pollution by means of volatile organic compounds in solvents [5] besides they do not have carcinogenic or toxic features. However, natural inks pH and heat sensitivity, low light fastness features and vulnerability to degradation are impractical [6, 7, 8]. Besides, natural inks prone to react with paper additives such as fillers, binders, bleaching chemicals. Even production method of cellulose may even cause color differences among paper [9, 10]. Therefore, experiments were carried out with various paper types. Paper properties effects the printing quality [11, 12]. Thus, there is a need for a comparison of paper properties of printed samples. In this research, bleached chemical paper (BCP), mechanical paper (MP) and surface treatment with calcium carbonate paper samples (CCP) were compared according to their color properties and strength properties.

2. Materials and Methods

Cyan (C), magenta (M), yellow (Y) and black (K) colors were tried to be obtained from *Indigofera tinctoria* L., *Rosa canina*, *Curcuma longa*, *Alkanna tinctora* plant extracts respectively. Each application was prepared with100 g of dried plant sample.

The extraction of natural substances was made with a hot water bath carried out at 60 °C for 12h. As a mordant 1% (w/w) Arabic gum and for conductivity and stability of the material 1 % (w/w) Na_2SO_4 were added to the samples whenever samples cooled 25 °C room

temperature. Maximum dry matter of the samples was 17 % (w / w). Distilled water was used in all processes.

Surface treatment with calcium carbonate paper samples (CP), paper made from mechanical pulp (VP) and paper made from bleached chemical pulp (PB) selected for printing application.

Commercial ink an ink from plant samples were applied to these paper and CIE L* a* b*. color measurements were evaluated with the Elrepho (Code 70, Type 991286, No 8803564). Paper surface were printed with commercial and natural ink samples using a commercial printer.

3. Results and Discussion

All paper samples were conditioned prior and after printing application at 23 °C and 50 % relative humidity for 24 hours according to ISO 287. Color values and strength properties performed in İstanbul University-Cerrahpasa, The Forest Product Chemistry and Technology Laboratory. Color values performed under 10° observer and a D65 light source CIE L * a * b * color results of printed paper were given in Table 1. In the table, 'X' represented extracted ink samples, 'O' represented commercial ink samples. Cyan, Magenta, Yellow and K (Black) are represented as their capital letter.

Table 1. CIE L * a * b * Color Results of Paper Samples.

Color Code	L*	a*	b*	Chroma
CP	93.20	2.74	8.16	-
VP	98.11	1.78	-2.09	-
PB	94.25	-0.46	6.10	-
XYCP	90.27	0.62	39.74	14.81
XYVP	98.35	-2.53	16.13	15.31
XYPB	93.64	-3.42	16.78	20.26
XMCP	76.65	7.01	3.86	18.41
XMVP	86.22	3.59	-2.15	13.06
XMPB	85.19	9.21	5.48	11.17
XCCP	64.97	-6.29	-8.30	9.57
XCVP	88.71	-3.58	-8.57	9.25
XCPB	86.17	-5.46	-4.16	8.61
XKCP	74.10	2.01	14.21	14.90
XKVP	84.31	1.78	15.18	16.09
XKPB	80.02	1.25	17.31	17.31
OYCP	77.83	16.41	0.36	19.03
OYVP	85.29	14.31	0.28	14.98
OYPB	81.14	14.21	0.31	14.78
OMCP	43.38	41.31	-18.13	43.91
OMVP	49.12	42.25	-16.34	45.55
OMPB	40.77	45.39	-14.21	47.56
OCCP	47.33	-23.72	-29.25	39.36
OCVP	50.25	-26.01	-31.41	41.54
OCPB	51.54	-30.65	-29.16	42.03
OBCP	31.05	0.38	1.05	1.21
OBVP	34.46	0.89	1.19	1.98
OBPB	31.32	1.07	3.02	2.71

Base paper samples properties were given in Table 2.

Table 2. Base Paper Properties.

Color Code	Basis Weight (g/m^2)	Burst Index (kPa* m^2/g)	Tensile Index M.D. (Nm/g)	Elongation (%)
CP	60.64	4.46	37.53	1.26
VP	61.24	5.38	45.59	1.68
PB	59.92	4.94	43.74	1.92

The results of basis weight and strength properties of ink applied paper samples were given in Table 3. Tensile index test was made machine direction (M. D.) of the samples due to paper position in the printing application. Extracted sample results were higher than commercial ink. The differences between results were due to increased viscosity of the extracted samples. Extracted ink applied samples strength results were decreased more than commercial ink applied samples (Table 3). Due to the acidic nature of natural ink, inter - fiber bonding was more damaged than commercial ink

The biggest obstacle of the application was buffer could not be used because of pH sensitivity of natural inks.

Table 3. Basis Weight of Ink Applied Paper Samples.

Color Code	Basis weight (g/m^2)	Burst Index (kPa* m^2/g)	Tensile Index M.D. (Nm/g)	Elongation (%)
XYCP	61.12	4.35	30.26	1.02
XYVP	62.36	5.21	42.21	1.28
XYPB	60.06	4.56	40.14	1.36
XMCP	61.14	4.34	34.21	1.01
XMVP	62.33	5.14	43.28	1.21
XMPB	60.09	4.31	38.96	1.39
XCCP	61.11	4.37	31.21	1.03
XCVP	62.37	5.20	43.14	1.11
XCPB	60.08	4.42	41.51	1.26
XKCP	61.19	4.40	33.31	0.98
XKVP	62.31	5.18	40.16	1.09
XKPB	60.02	4.01	39.74	1.14
OYCP	60.68	4.45	29.26	1.15
OYVP	61.29	5.00	40.21	1.21
OYPB	59.96	3.98	40.44	1.38
OMCP	60.67	4.40	23.35	1.10
OMVP	61.28	4.98	41.81	1.36
OMPB	60.01	4.46	40.16	1.54
OCCP	60.70	4.41	29.21	1.09
OCVP	61.32	5.06	41.51	1.20
OCPB	59.99	4.31	40.18	1.51
OBCP	60.69	4.34	34.15	1.13
OBVP	61.31	5,12	40.28	1.37
OBPB	59.98	4.52	41.02	1.42

After extracted ink application, paper samples photo was given in Figure 1. According to color results in Table 1

and Figure 1. mechanical pulp samples (VP) had lower results comparing to commercial ink due to lignin and hemicelluloses content of their structure.

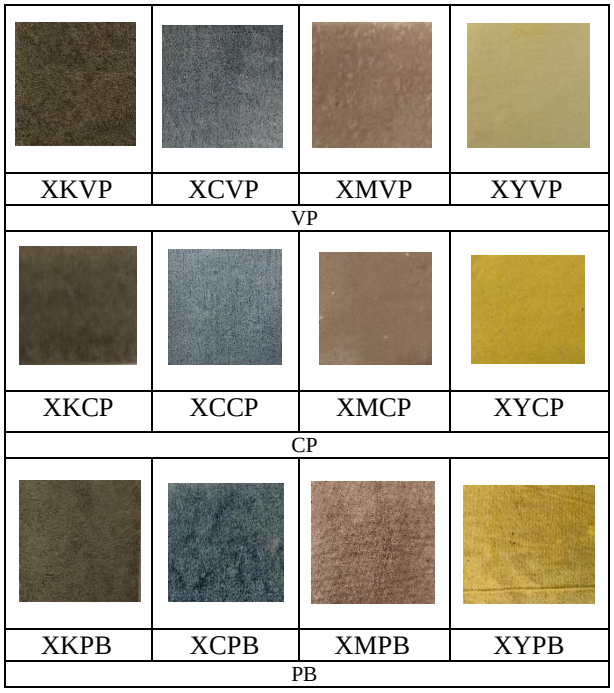

Figure1. Natural Ink Applied of Paper Samples.

4. Conclusion

The potential utilization of four main color of natural inks were examined and appropriate formulation improved. The commercial inks CIE L* a* b* values were compared to the natural inks. According to analysis of the color properties of the inks, it was obvious that magenta color values need to be improved with various additives. Especially *Rosa canina* extracts reacted with calcium carbonate surface coating material and gave purplish color results. Also paper made by mechanical pulp sample gave similar result. A possible cause of purplish color is the presence of hemicellulose and lignin in mechanical paper. The results indicate that the color results of natural ink and commercial ink were dependent on paper surface and chemical properties of the surface material.

Ethics

There are no ethical issues after the publication of this manuscript.

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