Comparative Analysis Of Print Ink Density Of Conventional And Soya-Based Ink On Paper Board Using Offset Printing Process

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ABSTRACT

The shift towards environmentally sustainable materials in the printing industry has led to increased interest in alternative ink formulations, such as soya-based inks, which offer reduced environmental impact compared to conventional petroleum-based inks. This study presents a comparative analysis of print ink density achieved using conventional and soya-based inks on paperboard substrates through the offset printing process. Ink density plays a critical role in determining print quality, influencing factors such as colour strength, image sharpness, and overall visual consistency. In this research, controlled printing trials were conducted using standard offset press conditions to ensure uniformity. Both ink types were applied to identical paperboard substrates, and ink density measurements were taken using a densitometer at designated control points. The aim is to evaluate the printing performance and visual strength of soya-based ink in relation to conventional ink, contributing to the understanding of its viability in commercial printing applications. The study offers insights into the print behaviour of sustainable inks and supports the industry's movement toward eco-friendly practices without compromising essential print quality parameters.

KEYWORDS: - Offset Printing, Ink Density, Conventional Ink, Soya-based Ink, Paperboard, Eco-friendly Printing, Densitometry, Sustainable Inks, Print Quality, Environmental Printing Solutions.

INTRODUCTION

The printing industry has witnessed a growing shift toward sustainable and eco-friendly practices in response to increasing environmental concerns and stricter regulations on volatile organic compounds (VOCs). One of the most significant areas of innovation lies in the development and adoption of alternative ink formulations, particularly soya-based inks, which offer a renewable and biodegradable substitute to conventional petroleum-based inks. These alternative inks are promoted for their lower environmental footprint, but their printing performance must be thoroughly evaluated to ensure that they meet the quality standards expected in commercial printing applications (Arai & Inoue, 2019).

Offset printing remains a dominant technology in the industry due to its high efficiency, print consistency, and adaptability to a wide range of substrates, including paperboards commonly used in packaging. One of the key parameters in assessing print quality in offset printing is ink density, which directly influences image sharpness, colour strength, and visual uniformity. Ink density refers to the amount of ink deposited on the substrate and plays a critical role in achieving desired visual and functional outcomes in printed products (Huber & Schmidt, 2017).

While soya-based inks are known for their environmental advantages, questions remain about their print behaviour, particularly in terms of ink density and coverage compared to conventional inks. Variations in ink density can affect not only visual appeal but also readability, branding accuracy, and customer satisfaction. Thus, a scientific comparison of print ink density between conventional and soya-based inks on paperboard substrates is essential (Patel & Mehta, 2019).

This study aims to evaluate and compare the ink density produced by conventional and soya-based inks using the offset printing process under standardized conditions. By analysing the print density across multiple samples and substrates, this research seeks to provide insights into the suitability of soya-based inks for maintaining high-quality print standards in an environmentally responsible manner.

RESEARCH OBJECTIVE

The primary objective of this research is to compare the print ink density achieved using conventional and soya-based inks on paperboard substrates through the offset printing process. This study aims to evaluate the printing performance of both ink types under controlled conditions to determine their effectiveness in producing consistent and visually strong prints. Specifically, the research focuses on measuring ink density using standardized densitometric methods to assess the amount of ink deposited on the substrate and to understand its impact on overall print quality. Additionally, the study seeks to examine whether soya-based inks can serve as a viable alternative to conventional inks without compromising essential print parameters. By providing a data-driven comparison, the research contributes to the ongoing pursuit of sustainable printing practices while maintaining high standards of print fidelity and commercial usability.

RESEARCH METHODOLOGY

This study adopts an experimental research methodology to analyse and compare the print ink density of conventional and soya-based inks applied on paperboard substrates using the offset printing process. The aim is to determine whether soya-based inks can achieve ink densities comparable to conventional inks, ensuring print quality is maintained while promoting environmentally sustainable alternatives. Three types of paperboard substrates were selected for this study: Art Paper Board, Folding Box Board (FBB), and Duplex Board. The Duplex Board was further divided into two variants which are White Back and Gray Back, to examine how the surface characteristics of the substrate influence ink density. All printing was conducted at Pinetree Packaging Pvt. Ltd., using a Heidelberg CD LX offset printing machine, known for its high precision and suitability for commercial packaging applications.

For each ink-substrate combination, more than 50 sheets were printed under standardized press conditions. From each set, 20 sheets were randomly selected to ensure unbiased data collection and to represent the overall print quality of the batch. Printing variables such as ink flow, roller pressure, paper feed, and blanket cylinder settings were kept constant across all samples to maintain consistency.

Ink density measurements were carried out using a densitometer, focusing on solid ink patches printed in primary colours (Cyan, Magenta, Yellow, and Black). Readings were taken from designated control strips on each sheet to obtain accurate and repeatable results. The ink density values were then tabulated and statistically analysed to evaluate the differences between the two ink types across various substrates.

This methodological approach provides a structured comparison of ink density performance and helps in assessing the feasibility of using soya-based inks in offset printing without compromising on essential print characteristics. The findings aim to support the broader adoption of sustainable printing materials in the packaging and commercial printing industry.

DATA COLLECTION & ANALYSIS

To assess and compare the ink density performance of conventional and soya-based inks on different paperboard substrates, a series of densitometric measurements were conducted on printed samples. The data was collected from randomly selected sheets to ensure representativeness and minimize sampling bias. Each ink type was evaluated under identical printing conditions to maintain consistency in results. The following tables and graphs present the recorded ink density values across various substrates, offering a visual and statistical overview of print performance. This analysis serves to highlight the differences in ink laydown and density uniformity between the two ink types, contributing to the overall understanding of their suitability for commercial offset printing applications.

Table 1, Average Print Ink Density of 20 samples printed by Conventional and Soya-based ink on Art Paper Board

	Conventional Ink	Soya-based Ink
Cyan	1.33	1.12
Magenta	1.37	1.17
Yellow	1.09	0.94
Black	1.85	1.66

The table 1, presents print ink density values for conventional and soya-based inks on art paper board. Conventional ink achieves higher density in Cyan (1.33), Magenta (1.37), Yellow (1.09), and Black (1.85) compared to soya-based ink, which measures 1.12, 1.17, 0.94, and 1.66 respectively. These differences indicate variations in ink vibrancy and opacity, relevant for assessing print quality and formulation efficiency.

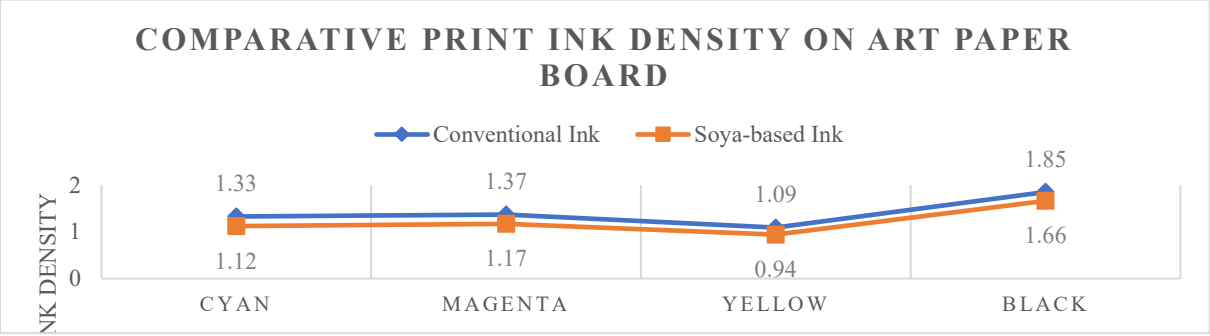

Fig.1, Comparative Print Ink Density of Conventional Ink and Soya-based Ink on Art Paper Board

Fig.1, illustrates a comparative analysis of print ink density between Conventional Ink and Soya-based Ink on Art Paper Board across Cyan, Magenta, Yellow, and Black. Conventional Ink consistently achieves higher density values, with Black showing the most significant difference (1.85 vs. 1.66). Cyan (1.33 vs. 1.12), Magenta (1.37 vs. 1.17), and Yellow (1.09 vs. 0.94) follow a similar trend. This comparison highlights the differences in colour vibrancy and opacity, offering insights into the performance of sustainable ink formulations in commercial printing applications.

Table 2, Average Print Ink Density of 20 samples printed by Conventional and Soya-based ink on Folding Box Board (FBB)

	Conventional Ink	Soya-based Ink
Cyan	1.22	1.07
Magenta	1.32	1.12
Yellow	1.03	0.87
Black	1.73	1.55

The table 2, presents the average print ink density of 20 samples printed using Conventional and Soya-based inks on Folding Box Board (FBB). Conventional Ink consistently exhibits higher density values across all colours: Cyan (1.22 vs. 1.07), Magenta (1.32 vs. 1.12), Yellow (1.03 vs. 0.87), and Black (1.73 vs. 1.55). These differences suggest stronger pigmentation and opacity in conventional inks compared to their soya-based counterparts, which may impact print vibrancy and substrate coverage efficiency.

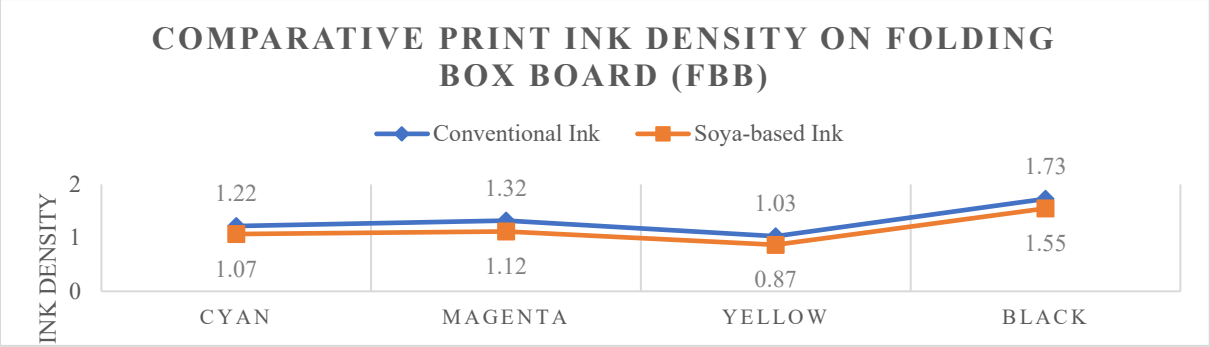

Fig.2, Comparative Print Ink Density of Conventional Ink and Soya-based Ink on Folding Box Board (FBB)

Fig. 2, compares print ink density between Conventional Ink and Soya-based Ink on Folding Box Board (FBB) across Cyan, Magenta, Yellow, and Black. Conventional Ink generally achieves higher density values for Cyan (1.12 vs. 1.07), Magenta (1.13 vs. 1.12), and Yellow (1.05 vs. 0.87), while Soya-based Ink exhibits a higher density for Black (1.55 vs. 1.43). These variations indicate differences in ink opacity and colour fidelity, offering insights into substrate interaction and print performance in offset printing applications.

Table 3, Average Print Ink Density of 20 samples printed by Conventional and Soya-based ink on Duplex White Back Board

	Conventional Ink	Soya-based Ink
Cyan	1.20	1.05
Magenta	1.25	1.07
Yellow	0.98	0.85
Black	1.65	1.53

The table 3, presents the average print ink density of 20 samples printed using Conventional and Soya-based inks on Duplex Board White Back. Conventional Ink consistently achieves higher density values across all colours: Cyan (1.20 vs. 1.05), Magenta (1.25 vs. 1.07), Yellow (0.98 vs. 0.85), and Black (1.65 vs. 1.53). These differences indicate stronger pigmentation and opacity in conventional inks compared to soya-based inks, which may impact print vibrancy and substrate compatibility.

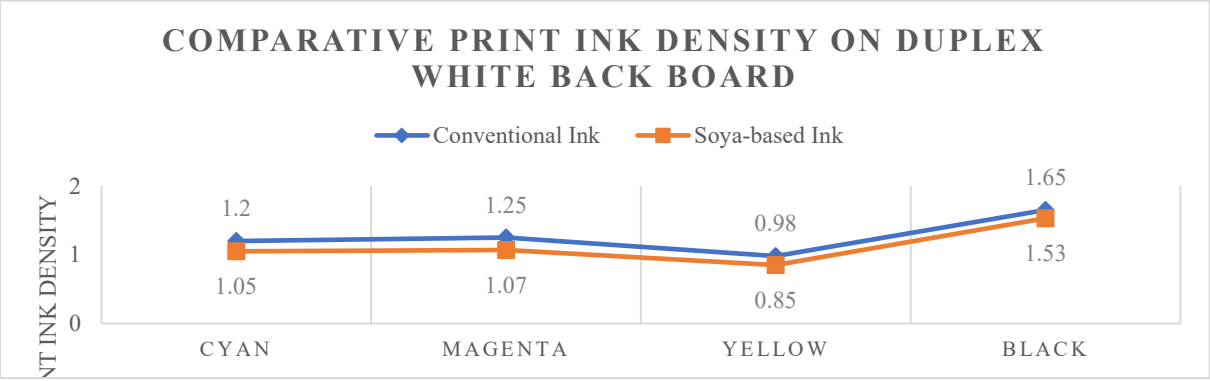

Fig.3, Comparative Print Ink Density of Conventional Ink and Soya-based Ink on Duplex White Back Board

Fig. 3, compares the print ink density of Conventional Ink and Soya-based Ink on Duplex White Back Board across Cyan, Magenta, Yellow, and Black. Conventional Ink consistently achieves higher density values, with Black showing the most significant difference (1.65 vs. 1.53). Cyan (1.2 vs. 1.05), Magenta (1.25 vs. 1.07), and Yellow (0.98 vs. 0.85) follow a similar trend. These variations highlight differences in opacity and ink film thickness, providing insights into print quality and substrate compatibility in offset printing applications.

Table 4, Average Print Ink Density of 20 samples printed by Conventional and Soya-based ink on Duplex Board Gray Back

	Conventional Ink	Soya-based Ink
Cyan	1.18	0.94
Magenta	1.19	1.05
Yellow	0.98	0.80
Black	1.62	1.47

The table 4, compares the average print ink density of Conventional and Soya-based inks on Duplex Board Gray Back across four colours. Conventional Ink consistently exhibits higher density values: Cyan (1.18 vs. 0.94), Magenta (1.19 vs. 1.05), Yellow (0.98 vs. 0.80), and Black (1.62 vs. 1.47). These differences highlight variations in ink opacity and colour strength, which can influence print vibrancy and substrate coverage efficiency.

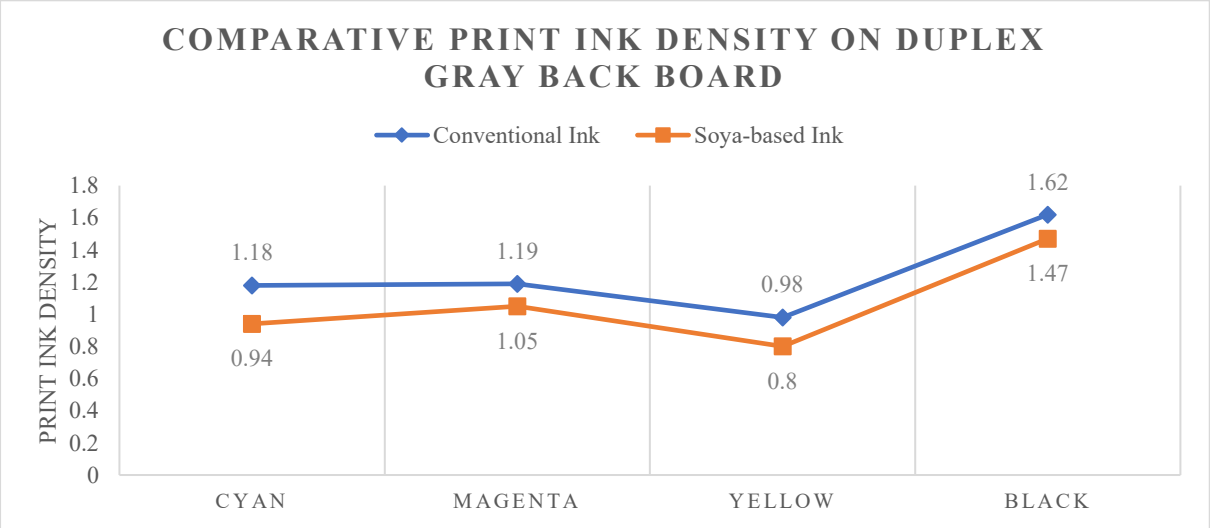

Fig.4, Comparative Print Ink Density of Conventional Ink and Soya-based Ink on Duplex Gray Back Board

Fig. 4, presents a comparative analysis of print ink density between Conventional Ink and Soya-based Ink on Duplex Gray Back Board across Cyan, Magenta, Yellow, and Black. Conventional Ink consistently shows higher density values, with Black exhibiting the most pronounced difference (1.62 vs. 1.47). Cyan (1.18 vs. 0.94), Magenta (1.19 vs. 1.05), and Yellow (0.98 vs. 0.80) follow the same trend, highlighting differences in ink formulation, opacity, and colour strength. This comparison provides valuable insights into print quality and substrate compatibility for commercial printing applications.

The table 5, provides a comprehensive comparison of print ink density values for Conventional and Soya-based inks across four different substrate types: Art Paper Board, Folding Box Board, Duplex

Board White Back, and Duplex Board Gray Back. Across all substrates and colours Cyan, Magenta, Yellow, and Black, Conventional Ink consistently achieves higher density values, indicating stronger pigmentation, opacity, and vibrancy compared to Soya-based Ink. The most pronounced differences appear in Art Paper Board, where Conventional Ink densities reach 1.33 for Cyan, 1.37 for Magenta, and 1.85 for Black, compared to 1.12, 1.17, and 1.66 for Soya-based Ink, respectively. Similar trends emerge in Folding Box Board, Duplex Board White Back, and Duplex Board Gray Back, though with minor variations based on substrate characteristics. This comparison underscores critical trade-offs between print richness and sustainability, providing valuable insights into ink performance, formulation optimization, and commercial printing applications for environmentally conscious materials.

Table 5, Average Print Ink Density of 20 samples printed by Conventional and Soya-based ink on Art Paper Board, Folding Box Board (FBB) and Duplex Board (White Back and Gray Back)

	Conventional Ink				Soya-based Ink			
	Cyan	Magenta	Yellow	Black	Cyan	Magenta	Yellow	Black
Art Paper Board	1.33	1.37	1.09	1.85	1.12	1.17	0.94	1.66
Folding Box Board	1.22	1.32	1.03	1.73	1.07	1.12	0.87	1.55
Duplex Board White Back	1.20	1.25	0.98	1.65	1.05	1.07	0.85	1.53
Duplex Board Gray Back	1.18	1.19	0.98	1.62	0.94	1.05	0.80	1.47

RESULTS & DISCUSSION

The comparative analysis of print ink density for conventional and soya-based inks on different paper boards using the offset printing process reveals distinct variations in ink performance and substrate interaction. Across all tested substrates i.e., Art Paper Board, Folding Box Board, Duplex Board White Back, and Duplex Board Gray Back, conventional ink consistently exhibits higher density values compared to its soya-based counterpart. This trend indicates that conventional ink provides stronger pigmentation and opacity, which translates to higher print vibrancy and colour richness.

Among the four colours (Cyan, Magenta, Yellow, and Black), the most pronounced density differences occur in the Black ink, where conventional ink achieves densities ranging from 1.62 to 1.85, while soya-based ink remains lower, between 1.47 and 1.66. Similar trends are observed in Cyan, Magenta, and Yellow, reinforcing the superior density retention of conventional inks. These findings suggest that substrate absorption and ink-film formation play crucial roles in determining final print quality.

While conventional inks demonstrate higher density and richer colour output, soya-based inks provide a sustainable alternative with acceptable print density levels. The comparatively lower ink density values may be attributed to differences in resin composition, curing behaviour, and pigment dispersion in soya-based inks. This highlights the trade-off between environmental sustainability and print fidelity, requiring optimization in formulation to enhance the performance of bio-based inks for commercial printing applications.

The study also indicates that different substrates exhibit varying ink absorption characteristics, affecting overall density retention. Art Paper Board supports the highest density values across both ink types, likely due to its smooth coating and optimized ink holdout. In contrast, Duplex Board Gray Back shows lower density values, suggesting higher ink penetration and diffusion.

CONCLUSION

The comparative analysis of print ink density confirms that soya-based inks exhibit slightly lower density values than conventional inks across various substrates. Conventional inks have higher SID due to denser pigments and quicker drying, allowing more ink to stay on the surface and Soya-based inks perform comparably, with slight variation depending on press speed and paper. However, the difference is not substantial enough to compromise print quality significantly. While conventional inks provide higher opacity and colour richness, soya-based inks offer an environmentally sustainable alternative with acceptable density levels for commercial applications. Given the growing emphasis on eco-friendly solutions, the adoption of soya-based inks presents a viable pathway for reducing environmental impact while maintaining satisfactory print vibrancy. With further advancements in formulation such as optimizing pigment concentration and resin compatibility, soya-based inks can effectively replace conventional inks without significant trade-offs in print density, making them a promising option for sustainable printing practices.

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