BonuPrint®, a Natural Printing Ink for Food and Nutraceutical Industries

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Introduction

Clean label is a consumer's movement, started in 1980s by stopping using the products containing E-Numbers listed on the packaging, with a goal to return to natural real foods with attention to packaging and ingredients of food [1, 3]. This movement has led the consumers to concern more about their food and consequently about their health which results in the rising of the manufacturer's attention towards the quality of food [1, 2]. In recent years, the term clean label has exponentially increased in food and beverage industries in Europe [3]. The well-known example of clean labels ingredients are natural food colors instead of the synthetic pigments [2].

Due to fast growth of clean label movement, the term natural color was defined by "Regulation (EC) No 1333/2008" which explains the detailed rules on the use of food additives [4]. This regulation was updated in 2010 (Commission Regulation 257/2010) and established a program for re-evaluation of approved natural colors [4]. Natural colorants are preparations obtained from a wide range of sources like vegetables, fruits, plants, minerals and other edible natural sources by physical and/or chemical extraction resulting in a selective extraction of the pigments relative to the nutritive or aromatic constituents [4]. The natural colorants can be divided into dyes (color that is soluble in a medium) and pigments (finely ground particles of color which are suspended in a medium) [5].

BonuPrint® (BP) is a fine, homogenous, liquid pigment dispersion for solid oral dosage form which provides possibilities to print logos, brand names or barcodes onto oral dosage forms [6]. Natural pigments can play an important role to increase the availability of the BP in different nutraceutical fields. Therefore, development of a BP with clean label approved natural pigments which provides similar characteristic like the standard BP can increase the range of its applications.

Printing inks such as BP are composed of liquid phase and solid phase [8]. The liquid phase is used as a vehicle system to carry solid contents, adjust viscosity and drying time of the ink, whereas the solid phase is a polymer responsible for film formation, a covering agent to provide enough opacity and color pigments to produce different colors [8]. Depending on the used liquid phase, they can be divided into water based and solvent based inks. Generally, the water based inks are a mixture of mainly water and a small amount of alcohol as vehicle system, whereas the solvent based inks are a mixture of alcohols as vehicle system [8]. The two types of inks have similar applications but the main difference is the easier handling and cleaning process of water based inks.

OBJECTIVES

In this study, water based BP named as "BonuPrint® F yellow 420.03" (BP yellow) and a solvent based BP named as "BonuPrint® F green 970.02" (BP green) were developed using clean labeled materials and compared with the Biogrund's standard BP named as "BonuPrint® F black 980.04".

Materials and Methods

Different mixtures of vehicle system for both water and solvent based BP were tested with natural pigments. The best composition of vehicle system and their applications in the formulation are shown in Table 1. Similarly, the solid contents used in the formulation of water and solvent based BP and their applications are listed in Table 2. A thinner solution (mixture of isopropanol and butanol) was used to dilute the BPs (Table 1).

Table 1: Vehicle systems and their applications in the formulation of natural BP

BP Base	Vehicle System	Application
Water based BP (BP yellow)	Water	Solvent
	Isopropanol	To adjust viscosity and drying time
	Propylene Glycol	Plasticizer
Solvent based BP (BP green BP green & BP F black 980.04)	Ethanol	Solvent
	Methanol	To adjust viscosity and drying time
	Butanol	To adjust viscosity and drying time
	Ammonium Hydrogen Carbonate	To adjust the pH
Thinner solution	Isopropanol/Butanol (1:1)	To adjust viscosity and drying time

Table 2: solid contents and their application in formulation of natural BP

BP Base	Solid contents	Application
Water based BP (BP yellow)	Hydroxypropylmethyl-cellulose	Viscosity enhancer
	Rice starch	Carrier
	Riboflavin	Natural pigment
Solvent based BP (BP green & BP F black 980.04)	Shellac	Polymer
	Rice starch	Carrier
	Cu-Chlorophyllin	Natural pigment
	Iron oxide black	Synthetic pigment

The viscosity of the BPs were measured with Ford Cup 4 by filling the cup and measuring the flowing time.

The drying time of the BPs were measured by making a film with the thickness of 30 µm using the Erichsen Baker-Applicator 286. The viscosity and the drying time of natural BP has been compared with the standard BP. It should be considered that the thin film was made on a plastic plate which has no absorption of the ink. Therefore, the measured drying time in this study is far away from the real life.

The color stability of the BP yellow and BP green was tested at 12, 24 and 48 hours of direct sun light exposure using Suntester XLS+ by making a 30 µm thick film. HunterLab ColorQuest XE was used to measure the color difference (ΔE) of the thin films against the reference film at each interval.

The developed natural BPs were tested on a printing machine with a steel printing plate (Etching depth: 25 µm) and Pad number 1571 (hardness: 10) in Printing International® N.V./S.A. Aalter, Belgium.

Result and Discussion

NATURAL PIGMENTS AND BP:

The solubility of different available natural pigments in ethanol were tested. Cu-Chlorophyllin was soluble and Riboflavin was partially soluble in ethanol whereas the other natural pigments were either insoluble or poorly soluble in ethanol. The natural pigments used in this study were Cu-Chlorophyllin and Riboflavin (Figure 1).

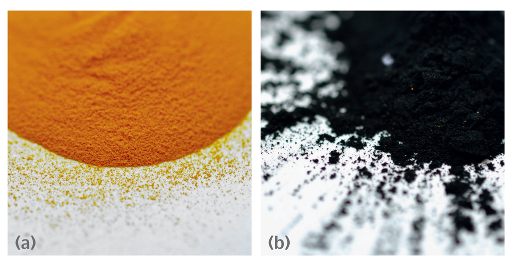

Figure 1: (a) Riboflavin powder (b) Cu-Chlorophyllin powder

VISCOSITY AND DRYING TIME:

The ideal viscosity of the pharmaceutical inks is between 45 – 65 seconds. The viscosity and drying time of BonuPrint® F black 980.04 were found to be 50.3 seconds and 131.0 seconds, respectively. The viscosity of the natural BPs were adjusted higher than the standard BP in order to enable the ability to adjust the viscosity and drying time by using a thinner solution based on the specific features of the printing machine. Table 3 shows the measured values of viscosity and drying time at each dilution level for BP yellow and BP green.

Table 3: Viscosity and drying time of BP yellow and BP green at different dilution level

Dilution series	BP yellow		BP green	
	Viscosity (sec)	Drying Time (sec)	Viscosity (sec)	Drying Time (sec)
0% dilution	112,3	136,3	106,0	86,0
5% dilution	82,7	135,3	80,3	132,7
10% dilution	60,7	131,3	47,7	151,3

The viscosity of BP yellow and BP green was greatly influenced by the addition of the thinner solution due to increase in the liquid phase of the BP. The calculated R-square value (R^2) from the linear trendline of viscosity for both BP yellow and BP green shows a linear decrease in the viscosity of the BP at each level of dilution. The R^2 value for BP yellow and BP green were found to be 0.9927 and 0.9952, respectively. Figure 2 shows the viscosity of the BP yellow and BP green at each dilution level and the viscosity of the BonuPrint® F black 980.04 as reference.

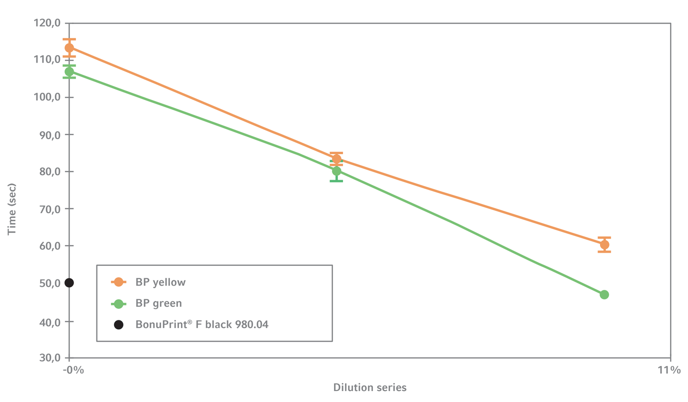

Figure 2: The viscosity of the BP yellow (orange line) and BP green (green line) at each dilution level and the viscosity of the BonuPrint® F black 980.04 (black point) as reference. The viscosity of both BPs were reduced due to addition of thinner solution.

The drying time of the BP yellow was not greatly affected by the addition of the thinner solution. The strong intermolecular force of water is the reason for nearly constant drying time of BP yellow. The drying time in BP yellow can be altered by increasing the concentration of isopropanol in the composition of thinner solution. Unlike BP yellow, the drying time of the BP green was greatly influenced by the addition of the thinner solution. The intermolecular force of butanol and isopropanol is higher than intermolecular force of ethanol and methanol. Therefore, the addition of thinner solution was caused an overall increase in the intermolecular force of the BP green resulting an increase in the drying time. Figure 3 shows the drying time of the BP yellow and BP green at each dilution level and the drying time of the BonuPrint® F black 980.04 as reference.

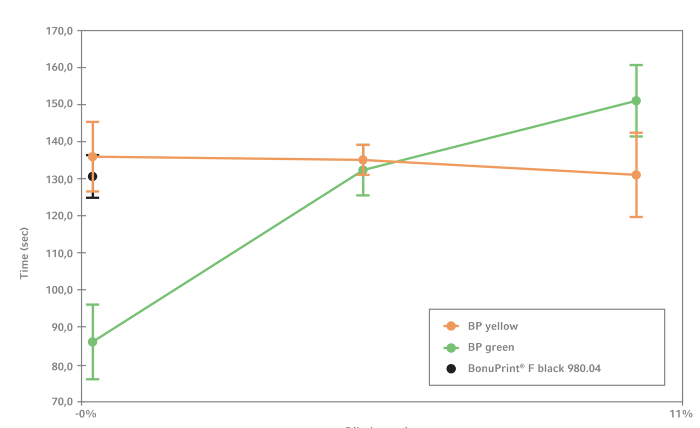

Figure 3: The drying time of the BP yellow (orange line) and BP green (green line) at each dilution level and the drying time of the BonuPrint® F black 980.04 (black point) as reference. The drying time of the BP yellow remained nearly constant due to the strong intermolecular force of water whereas, the drying time of BP green was increased due to intermolecular force of thinner solution.

LIGHT STABILITY:

The Suntester XLS+ is used for the light stability test. The Suntester XLS+ simulates sun light. Eight minutes light exposure from the Suntester is equal to one hour of sun exposure. Table 4 shows the measured ΔE of BP yellow and BP green against reference at each interval.

Table 4: The measured ΔE of BP yellow and BP green against reference at each interval

BP	ΔE at 12 h	ΔE at 24 h	ΔE at 48 h
BP yellow	1.38	1.45	1.68
BP green	2.31	2.44	2.99

According to Biogrund's standard, the tolerated color difference against the reference color for Riboflavin and Cu-chloropyllin is 3.5. At 12 hours, there is an increase in ΔE for both samples. However, any changes in color cannot be seen visually. At 24 hours, there is no significant color change. At 48 hours, there is slight change in ΔE but the color of both BPs are in the tolerated range. That shows that the BP yellow and BP green are stable against sun light.

PRINT QUALITY:

The print quality can be defined by sharp, clear and intense monogram on the substrate. Figure 4 shows a printed tablet using BonuPrint® F black 980.04.

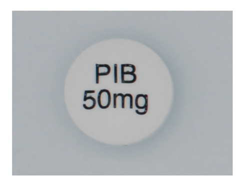

Figure 4: A printed tablet using BonuPrint® F black 980.04

Figure 5 shows different printed tablets using the BP green at each dilution level. The 0% dilution tablet has a sharp, clear and intense monogram. The sharpness and the clearness of the tablets remain the same but at 5% and 10% dilution levels the intensity of the color has slightly reduced which is not remarkable easily. Figure 6 shows a printed tablet using 0% dilution BP yellow. The BP yellow had almost a similar behavior as BP green, but the intensity of the color has subjected to smaller change than BP green at each dilution level.

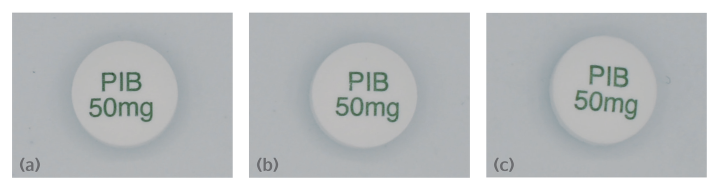

Figure 5: Printed tablets using BP green at (a) 0% dilution, (b) 5% dilution, (c) 10% dilution

Figure 6: Printed tablets using BP yellow at 0% dilution

Conclusion

The developed water based and solvent based BP with natural pigments were tested and compared with BonuPrint® F black 980.04. The starting viscosity of BP yellow and BP green was adjusted higher than the standard BP in which the viscosity was altered by using the thinner solution without affecting the printing quality. After 10% dilution of both BPs, the viscosity was similar to that of standard and in the ideal range of pharmaceutical inks. The drying time of the BP green was greatly affected by the addition of the thinner solution which was similar to standard BP, whereas the drying time of BP yellow was not affected by the addition of thinner solution. The drying time of BP yellow can be changed by increasing the amount of isopropanol in the thinner solution. The results obtained from the light stability test were confirmed the color stability for both products.

In conclusion, the BP yellow and BP green are promising high adopt-ability to different printing machines, easy handling and high printing quality which can be used in food and nutraceutical fields.

Reference:

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