Evaluating the effects of plant-derived colourants on the physicochemical characteristics and colour stability of pressed eyeshadows

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Introduction

CI 15850:1, known in the United States (US) as Red D&C No. 7, is banned for use in cosmetics around the eye area by the US Food and Drug Administration (FDA). With both eye makeup market and the vegan beauty market predicted to grow in the coming years [1], it is pertinent to explore the use of plant-based alternatives as cosmetic colourants, especially for the eye area.

Anthocyanins have been widely explored as plant-based colourant alternatives in the food industry [2,3], however there is little research on their use in cosmetic products. Anthocyanins have been suggested not only as alternatives to synthetic colourants, but also as cosmetic active ingredients, due to their antioxidant and UV protection properties [4]. However, anthocyanins are prone to chemical changes, which could affect their colour [5].

The aim of this study was to evaluate the efficacy of natural anthocyanins as potential plant-based colourants in pressed eyeshadows as an alternative to the synthetic pigment CI 15850:1 (D&C Red No.7). ***Raphanus sativus* (Radish) Root Extract** (Red Radish colourant), whose red pigmentation is largely attributable to anthocyanin accumulation [6], was selected for this study due to its reported similarity in colour to CI 15850:1 [4].

Materials & Methods

Table 1: Pressed powder formulations

Phase	INCI	% (w/w)
	Talc	Ad 100%
	Zinc Stearate	5.0
	Methylparaben	0.2
	Propylparaben	0.1
	CI 15850:1 (OR) Raphanus Sativus (Radish) Root Extract (and) Citric Acid (and) Maltodextrin	10.0
	Heptyl Undecylenate	3.0 - 6.0 - 9.0

Aerated and tapped bulk densities [7] → Calculation of Hausner Ratio/Carr's Index [7]

Angle of repose [8]

→ Characterisation of powder flowability and compressibility [7,8]

Pressing @ 1000 or 2000 psi

Colour Measurements

- Konica Minolta CM-2600D spectrophotometer;
- L*a*b* measurements with D65 reference illuminant and including specular component;
- ΔE calculated according to equation 1:

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2}$$

Drop Test

- 3 drops, 30 cm height;
- According to ASTM D5276 [9].

Hardness (g)

- TA.XTplus Texture Analyser;
- 2 mm needle probe;
- Eyeshadow test protocol.

Payoff (% mass loss)

- TA.XTplus Texture Analyser with makeup brush;
- Method by Baltazar et al. [10].

Xenon Weathering

- SUNTEST CPS +;
- 24 +/- 1 h @ 765 W/m² as per QAC-MC-151 [11].

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Results

Table 2: ΔE of pressed powders obtained at 1000 psi and 2000 psi after Xenon test; HU - Heptyl Undecylenate

Pressed Powder	ΔE 1000 vs 2000 psi
Control, 0% HU	0.651
Control, 3% HU	1.199
Control, 6% HU	0.321
Control, 9% HU	1.045
Red Radish colourant, 0% HU	1.715
Red Radish colourant, 3% HU	2.594
Red Radish colourant, 6% HU	4.165
Red Radish colourant, 9% HU	4.928
CI 15850:1, 0% HU	1.590
CI 15850:1, 3% HU	2.914
CI 15850:1, 6% HU	1.426
CI 15850:1, 9% HU	1.577

Bulk Powder Testing and **Colour Measurements after Pressing**

- Heptyl Undecylenate (HU) decreased powder flow and increased compressibility, as expected; this effect was larger with the Red Radish colourant;
- ΔE between press strengths was higher when HU was added to Red Radish pigment (Table 2);
- ΔE was higher between 3% and 6% HU as compared to 6% and 9%, in line with previous work [10], with this effect being more prominent with the Red Radish pigment.

Xenon Weathering Test

- Samples with CI 15850:1 remained similar in colour for both press strengths;
- Samples with Red Radish colourant visibly degraded (ΔE > 2.5), with this effect being higher for powders pressed at 1000 psi.

Drop Test

- HU increased the resilience of all pressed powders, proportionally with an increase in HU concentration, as well as an increase in press strength, in line with previous work [10].

Hardness (Figure 1)

- Powders pressed at 2000 psi were harder than those pressed at 1000 psi, as expected;
- The hardness of pressed powders with 9% HU decreased after increasing up to 6%, but this did not affect the drop test results.

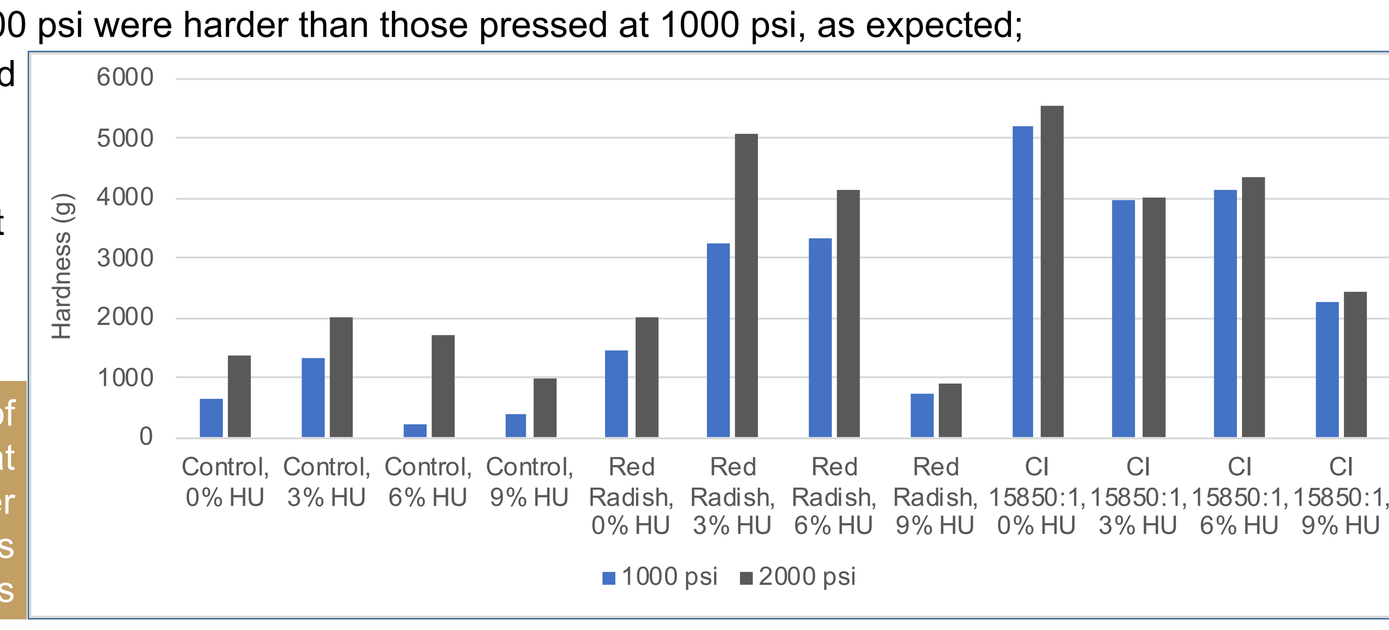

Figure 1: Hardness (g) of pressed powders at different binder concentrations and press strengths

Payoff (Figure 2)

- Powders pressed at 1000 psi had better payoff (higher mean % weight reduction), as expected;
- An increase in HU concentration resulted in a reduction of payoff, in line with the drop test results;
- Powder cohesiveness proportionally increased with HU concentration, despite a drop in hardness (from 6% to 9% HU).

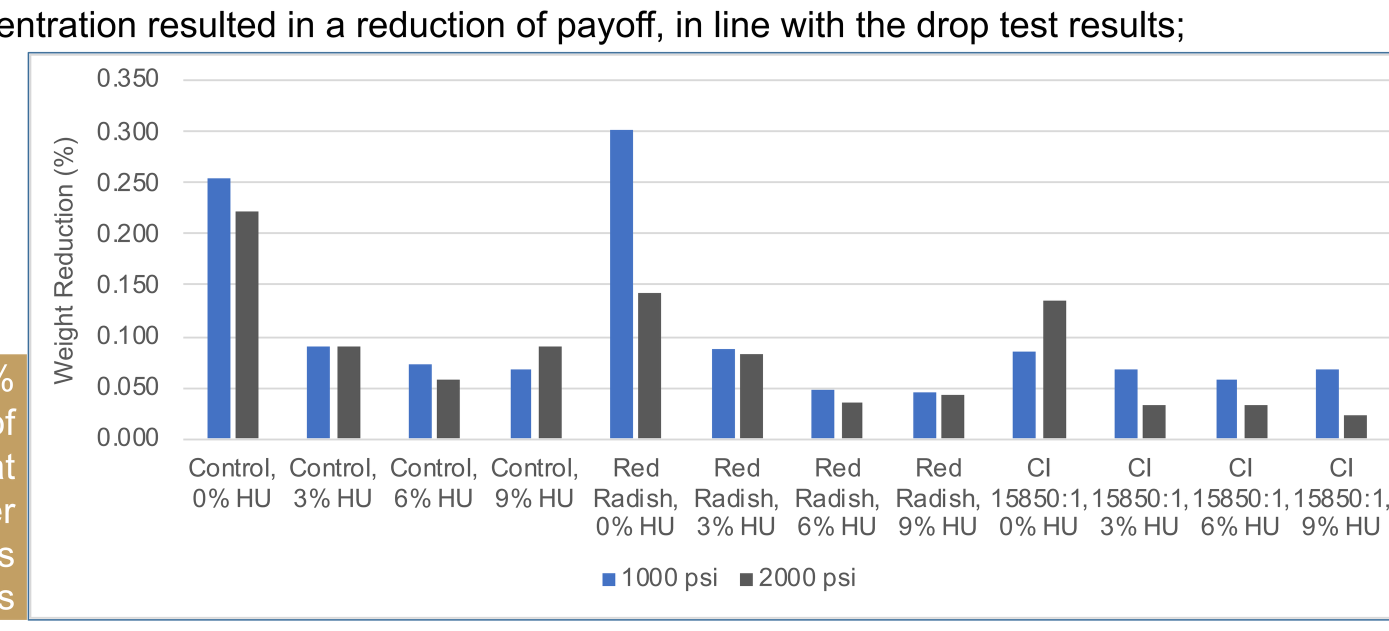

Figure 2: Payoff (% weight reduction) of pressed powders at different binder concentrations and press strengths

Discussion & Conclusion

This study aimed to assess the potential use of Raphanus sativus (Radish) Root Extract as a plant-based alternative to CI 15850:1, which is restricted in eye products in the USA.

Although the physical properties of pressed powders with Red Radish colourant were different from pressed powders with CI 15850:1, the results obtained for colour measurements at different press strengths, drop test, hardness and payoff show that it is possible to create pressed powders with plant-based colourants with the desired physical properties by carefully selecting ingredients and their concentrations.

Heat and light have been described as important factors contributing to the degradation of anthocyanins [5]. Although the Red Radish colourant has shown to be stable in lipstick formulations [4], the results obtained by the Xenon Weathering test have shown that the same does not to apply to pressed powders.

This study has shown that the **Raphanus sativus (Radish) root extract remains a potential substitution for CI 15850:1**, providing that the formulation and packaging are optimised to reduce the photo- and thermal degradation of its anthocyanins.

References

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