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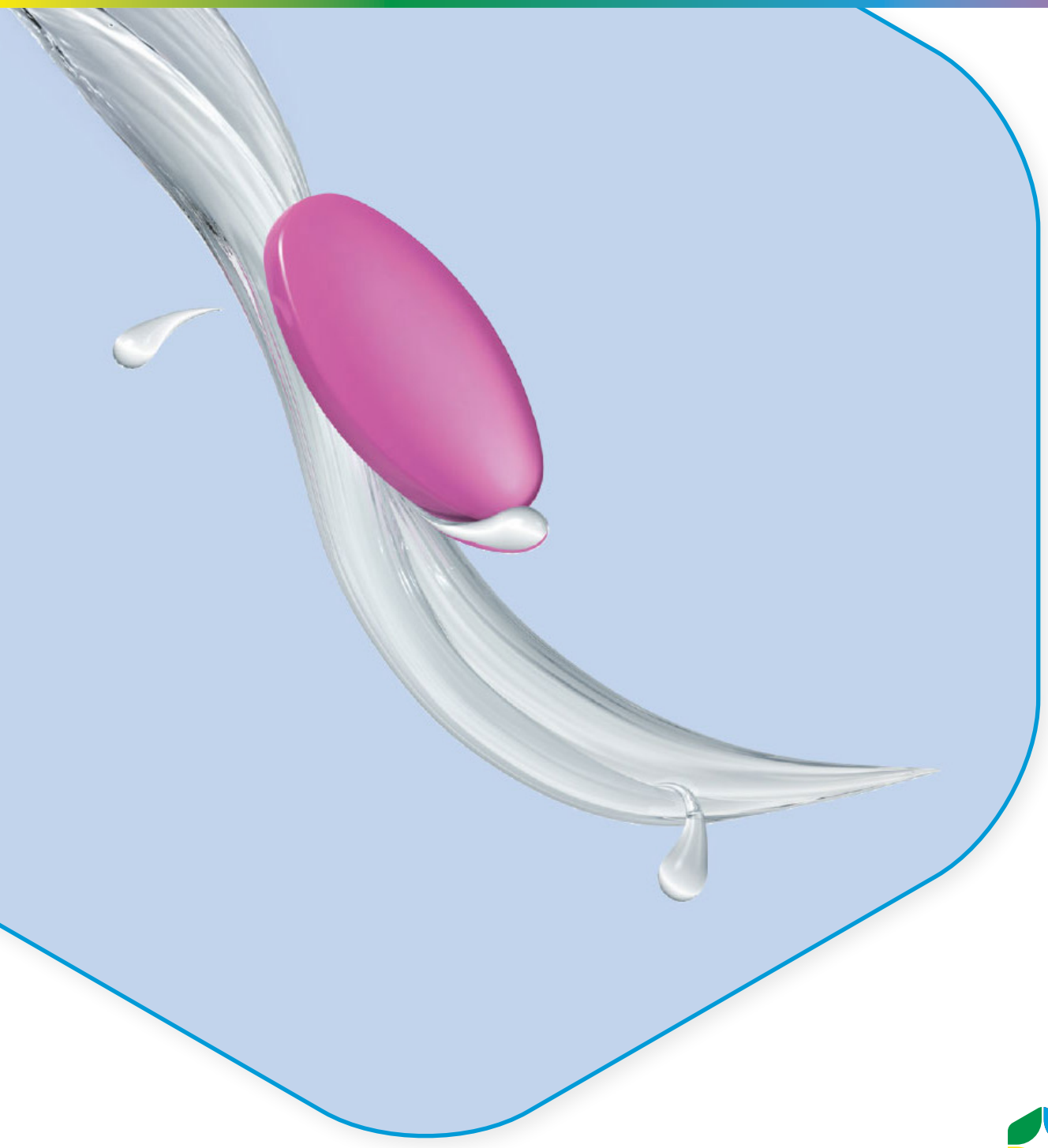
Easy Swallow Film Coating System



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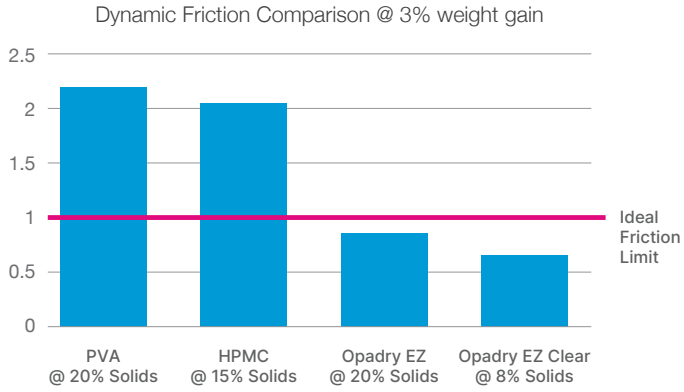
Opadry® EZ

Easy Swallow Film Coating System

Opadry® EZ, easy swallow coatings, is a scientific breakthrough that dramatically improves tablet mobility, reducing the probability of sticking in the throat or esophagus. When compared to other film coatings, once wet, the reduced friction on the surface of an Opadry EZ coated tablet results in better slip. The improved tablet flow, combined with a glossy finish for added elegance, encourages better patient compliance and consumer appeal.



Make Uncoated Tablets Easy to Swallow

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- A clear top-coat further enhances gloss and improves aesthetic appearance

Improve Slip of Currently Coated Products

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The Critical Attributes of a Film Coating to Make a Tablet Easy to Swallow

J.K. Czarnocka[1], Ali Rajabi-Siahboomi[2], Daniel To[2], Jason Teckoe[2], H. K. Batchelor[1]

[1]University of Birmingham, UK; [2]Colorcon, Inc., Harleysville, PA, USA, www.colorcon.com

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Purpose

Issues in swallowing tablets have been reported in several studies, with up to 37% of adults reporting problems with swallowing [1,2,3]. Specific tablet attributes that caused issues included size and texture. Tablet size is typically dictated by the dose required, yet tablet finish may be optimized by the use of coatings.

Objective

This study investigated the mouthfeel and ease of swallowing of coated and uncoated tablets in a healthy adult population, to determine which factors were most associated with improving the swallowing experience.

Methods

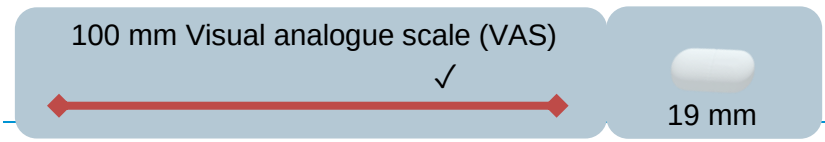
A single centre cross-over study was used to measure the mouthfeel and swallowing experience of four 19 mm placebo tablets. One tablet was uncoated and the other three were coated as detailed in Table 1 (all tablets were provided by Colorcon Inc.).
All participants completed a background questionnaire and then received the same 4 samples in a randomized order. Ethical approval was obtained from the University of Birmingham (ERN_17-0883 (17-1074)).

Table 1: Specification of Tested Tablets

	Tablet specification	Short name
1	Uncoated placebo tablet	Uncoated
2	Opadry® (Complete Film Coating System) 03F white coated placebo tablet	Opadry
3	Opadry® EZ (Easy Swallow Film Coating System) white coated placebo tablet	EZ
4	Opadry® EZ (Easy Swallow Film Coating System) white and clear top-coated placebo tablet	EZ-EZ

Study Activity

Participants were asked to score the mouthfeel after holding the tablet for 10 seconds in their mouth based on the following parameters: smoothness, stickiness, slipperiness, and palatability, using visual analogue scales (VAS). They were also asked to rank the tablets in order of preference for ease of swallowing. The time taken to swallow the tablet and the volume of water used to aid the swallowing were also recorded.



Statistical analysis

Wilcoxon's test was used to determine specific differences between samples; this was used to look at differences between the three coated tablets and significant differences were reported when $p<0.0167$ (derived from $p=0.05$ divided by the 3 samples; 0.05/3).

Results

Mouthfeel

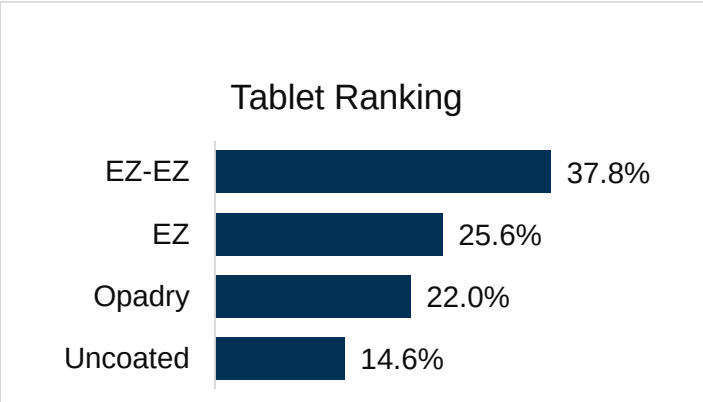
In the analysis of the mouthfeel parameters the uncoated tablet was always statistically significantly worse compared to the three coated tablets based on the VAS scores, $p<0.01$ from the Wilcoxon's test. Pairwise comparisons between the coated tablets showed significant differences as reported in Table 2.

Table 2: Mouthfeel parameters for the coated tablets

	Order of preference found	Significant differences reported
Roughness: Smooth > Rough	EZ-EZ > Opadry > EZ	EZ-EZ > EZ ***
Adhesiveness: Not Sticky < Sticky	EZ-EZ > EZ > Opadry	EZ-EZ < Opadry*** EZ < Opadry***
Slipperiness: Slippery > Not Slippery	EZ-EZ > EZ > Opadry	EZ-EZ > EZ ** EZ_EZ > Opadry*** EZ > Opadry*
Palatability: Pleasant > Unpleasant	EZ-EZ > EZ > Opadry	EZ-EZ > Opadry***

Ranking of easy-swallowing

When the tablets were ranked in order of preference based on overall swallowing experience, the favorite sample was EZ-EZ which was the first choice for 37.8% of participants followed by EZ, Opadry was third and the least popular was the uncoated tablet.



Water

All coated tablets required less volume of water to swallow compared to the uncoated tablet ($p<0.05$).

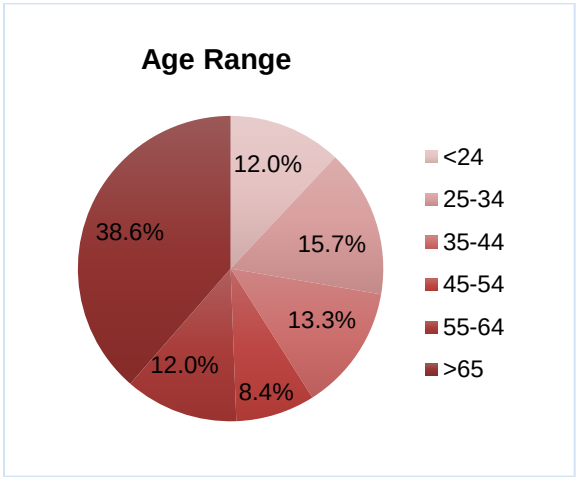
	Uncoated Tablet	Coated Tablet
		
Median	35.9 mL	26.5-28.8 mL

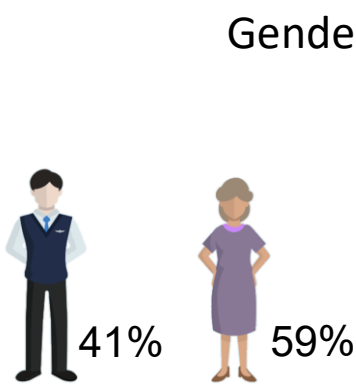
Time

The time taken to swallow tablets ranged from 1 to 49 seconds. This parameter was measured by participants and was calculated from the time of placing the tablet in the mouth to feeling that the swallowing was complete. Both the EZ-EZ and the Opadry coated tablets were swallowed significantly quicker than the uncoated tablet with median times being 6 seconds for the coated tablets and 7 seconds for the uncoated tablet ($p<0.05$).

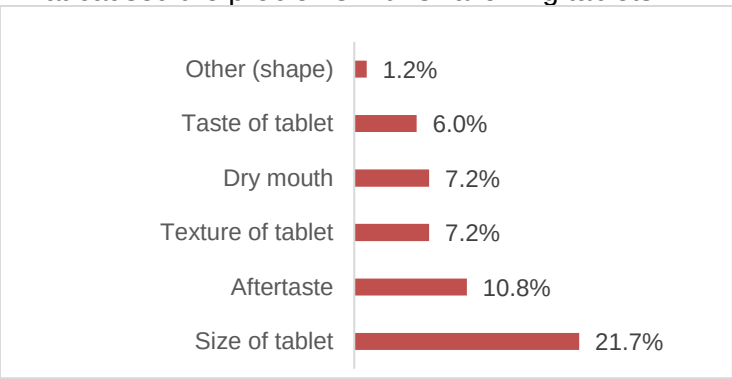
Demographics

The study included 83 non-smoking, healthy adults between 18 and 75 years of age, with those over 55 years making up half of the participants. 26.8% (n=22) of those recruited reported previously having difficulty in swallowing tablets, with 6 of those mentioning that tablet texture was a specific issue.





What caused the problems with swallowing tablets?



Conclusions

These results show that the mouthfeel results relate to the overall swallowing experience. The slipperiness score was the only one of the four parameters measured that discriminated between all the tablets and placed them in the same order as the overall swallowing experience. Thus, the slipperiness of the tablet is the best predictor of the ease-of-swallowing.

Key points

- ✓ This study showed that uncoated tablets are inferior to coated tablets in terms of ease of swallowing.
- ✓ The EZ-EZ tablet was the favored tablet in terms of mouthfeel and ease of swallowing.
- ✓ Data suggests the level of slipperiness of tablets is an optimal measure to rank the tablets for ease of swallowing.

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Developing methodology to evaluate the oral sensory features of pharmaceutical tablet coatings

J.K. Hofmanová[a], A. Rajabi-Siahboomi[c], S. Haque[b], J. Mason[a], J. Teckoe[c], D. To[c], H.K. Batchelor[a,*]

[a] School of Pharmacy, University of Birmingham, Edgbaston, B16 2TT, UK
[b] Institute of Clinical Sciences, University of Birmingham, Edgbaston, B16 2TT, UK
[c] Colorcon Inc. Global Headquarters, 275 Ruth Road, Harleysville, PA 19438, USA

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ABSTRACT

Acceptability of medicines is critical for effective pharmacotherapy. The aim of this study was to investigate the oral sensory properties of tablet coatings to determine how mouthfeel can improve acceptability. A randomised double-blind study was performed in 84 adult volunteers (51% ≥55 years). Each participant received 4 placebo tablets (3 coated and 1 uncoated) to evaluate (i) ease of swallowing and (ii) palatability. Visual analogue scales (VAS) were used to capture sensory parameters. Acceptability was assessed using the following parameters: ease of swallowing; amount of water taken with the tablet; rank order of preference; roughness; adhesiveness and slipperiness. Ease of swallowing was determined to be the most sensitive measure of acceptance. The best coating was the one that was reported to be the most slippery and smooth.

The presence of a coating improved ease of swallowing, mouthfeel and overall palatability. This study demonstrates that slippery coatings improve acceptability of tablets. The study also demonstrates the value of VAS to measure the sensory attributes of coated tablets.

1. Introduction

Patient acceptability of medicines is fundamental in the development of pharmaceutical dosage forms (Liu et al., 2014). Assessing acceptability of medicinal products in their target population is a requirement of the European Medicines Agency in order to obtain a marketing approval (EMA, 2006, 2017). For oral drug delivery, tablets are the most common and preferred choice of dosage form (Mohr, 2009). For any oral formulation, ease of swallowing is an important determinant of patient acceptability. Ease of swallowing is affected by both medicinal product features (i.e. dosage size, shape, slipperiness of the coating), as well as the patient's ability (physiological and/or psychological) to swallow (EMA, 2017). In general, larger solid oral dosage forms are reported to be more difficult to swallow but shape also has an influence. Round tablets have been reported to cause fewer difficulties compared to oblong and oval tablets (Schiele et al., 2013).

Another determinant of acceptability is palatability. The main factors that affect palatability of solid oral dosage forms are taste, texture and mouthfeel (Fields et al., 2015; Liu et al., 2016; Schiele et al., 2013). While taste is a sensation caused by chemical interaction of formulation components with taste buds on the tongue, texture and mouthfeel are more complex and multifactorial in nature. Texture embraces "all the mechanical, geometrical and surface attributes of a product perceptible by means of mechanical, tactile, and, where appropriate, visual and auditory receptors", as defined by the International Standards Organisation (ISO, 1994). Whereas mouthfeel encompasses the tactile properties perceived from the point a formulation is placed in the mouth to when it is swallowed (Guinard and Mazzucchelli, 1996).

Many manufacturers apply film coatings to tablets. Reasons for this include: aiding identification; improved stability; control of drug release rates and taste masking of bitter drugs (Joshi and Petereit, 2013). Typical polymers used include hydroxypropyl methylcellulose (HPMC); polyvinyl alcohol (PVA); polyvinyl alcohol-polyetheylene glycol graft copolymer (PVA-PEG); acrylic copolymers with plasticizing agents such as polyethylene glycol, triacetin or others. Film coatings can make a tablet more palatable by taste masking and provision of a smooth outer surface texture (Fields et al., 2015) to improve mouthfeel, which can improve acceptability. In addition, they can improve ease of swallowing of a tablet. By inhibiting the disintegration of the tablet in the mouth, a polymer film coating enables a tablet to be swallowed intact and the polymer layer can enhance the gliding properties of the tablet surface within the mouth during the swallowing action i.e. provide a slippery

* Corresponding author at: University of Birmingham, Edgbaston, Birmingham B15 2TT, UK.
E-mail address: h.k.batchelor@bham.ac.uk (H.K. Batchelor).

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layer (Mahdi and Maraie, 2015). Multiple studies have confirmed that coating a solid dosage form can improve the swallowing experience and taste (El Edelbi et al., 2015; Mahdi and Maraie, 2015; Uloza et al., 2010).

Unpleasant taste and mouthfeel have been found to impact patient adherence in paediatric (Venables et al., 2015) and adult populations (Schiele et al., 2013). Yet, there is limited understanding of which mouthfeel attributes have the largest impact on the acceptance of solid dosage forms. Similarily, awareness of tablet sensory characteristics that are discernible by patients is needed. Evaluation of taste and texture is typically undertaken using sensory analysis. Whilst food sensory analysis is well studied, the field of pharmaceutical sensory analysis lacks clear guidance (Tuleu, 2016). Pharmaceutical sensory studies conducted to date use a range of methodologies and some levels of discrepancies exist amongst them, such as: the number of subjects involved, type of control sample, scales and measures used, definition of acceptance criteria, and level of training of the participants. Further work is needed to determine methodology for testing the appropriateness of drug products (Drumond et al., 2017).

Previous clinical swallowing studies used various methods, to collect data: as observations (Kluk and Sznitowska, 2014); using a descriptor scale (El Edelbi et al., 2015) or VAS (visual analogue scale) (Hayakawa et al., 2016). The VAS provides continuous data, which is suitable for statistical analysis and allows detection of small differences between samples (Mistry et al., 2017). Similar methodologies have been used to assess the mouthfeel of medicines. Notable examples include *in vivo* evaluation of perceived grittiness and roughness of oral dosage forms depending on the formulation factors (i.e. particle size) (Kimura et al., 2015; Lopez et al., 2016). Lopez et al. (2016) concluded that the perceived oral grittiness of solid multi-particulate formulations is significantly reduced when particles are dispersed in a viscous vehicle, while Kimura et al. (2015) established that a rough mouthfeel was more intense for ODT with granule size ≥200 μm. There are very few reports of studies performed that evaluate the palatability, excluding taste, of oral dosage forms. The objective of this study was to investigate the ease of swallowing and oral sensory properties of tablet coatings applied to placebo tablets. The study used a crossover, single centre design to assess the ease of swallowing and sensory perception of the mouthfeel of placebo tablets coated with different film coatings vs. uncoated ones. The oral sensory perception of tablet-coating attributes that are critical to improve swallowing and acceptability are as yet unexplored. This study investigates the effect of tablet coatings on swallowability and mouthfeel in an adult population with an emphasis on older (> 55 years) adults. These data will inform the application of coatings which optimise acceptability of tablets.

2. Materials and methods

2.1. Study population and setting

The study was approved by the Ethical Committee of the University of Birmingham (ERN_17-0883 (17-1074)). All sessions were conducted within the premises of the School of Pharmacy at the University of Birmingham. The participants were recruited from the University of Birmingham and associated networks via advertisements and newsletters. The eligibility criteria included non-smoking, healthy adults between 18 and 75 years of age, who did not self-report any conditions that might compromise their taste or smell, nor any issues in ability to swallow a tablet. Prior to the study written consent was collected from all participants.

The sample size analysis showed that to detect a 10 point difference on the scale with a power of 80% and $\alpha = 0.05$ there was a need for 38 evaluations per sample. An older population (≥55 years) was targeted to better reflect the population who take the most medication and may have a higher incidence of swallowing disorders (NHS Digital, Baijens et al., 2016).

2.2. Background questionnaire

Participants completed a background questionnaire to record demographics including: age range; gender; and previous problems with swallowing tablets including what caused these difficulties. Information on current tablet/capsule intake was also recorded. (The background questionnaire is available in Appendix A).

2.3. Materials

White capsule shaped placebo tablets (caplets) were manufactured under GMP conditions and used in this study. The caplet shape and large dimension tablets, 19 × 9 × 7 mm, were selected for this study to reflect the tablet features most likely to cause swallowing problems (Schiele et al., 2013). Tablets were prepared by direct compression on a 27-station compression machine (CMBGD-27/MT, CADMACH, India) fitted with 12 sets of D-tooling and 950 mg target weight. Tablet properties were as follows, hardness: 125 ± 4 N, average weight: 951.6 mg ± 3.0%, friability: 0.1% and disintegration time: 1 min 53 s. These placebo tablets were composed of: lactose monohydrate (69%), microcrystalline cellulose (15%), Starch 1500® (Partially Pregelatinized Maize Starch, 15%), colloidal silica (0.5%) and magnesium stearate (0.5%).

The average porosity (P) of the tablets was 23%, as calculated from density (ρ): $P = \left(1 - \frac{\rho_{apparent}}{\rho_{true}}\right) \times 100$, where $\rho_{apparent} = 1.8$ g/cm^3 and $\rho_{true} = 1.54$ g/cm^3 Tablets were then coated (coating equipment: NEOCOTA 40D dual pan coater) under GMP conditions using the Opadry® film coating systems; (Opadry white, Opadry EZ white and Opadry EZ clear (Colorcon, USA) (Table 1). These aqueous based film coatings were sprayed onto tablets providing a weight gain of 3% (w/w) film coat, and 1% (w/w) clear top coat (in one case), under the process conditions shown in Table 2.

2.4. Tablet sample assessment

Both (i) ease of swallowing and (ii) palatability of placebo tablets were assessed within a single visit. In both aspects of the study participants received four tablets. To reduce carry over and sequential bias the following methods were used: four samples were presented in a randomized order in all possible sequences, and a palate cleanser was given before each sample. Palate cleansing entailed drinking room temperature spring water, followed by a piece of lightly salted cracker (Jacob's, or Schar gluten free) and followed again by room temperature spring water (Lucak and Delwiche, 2009).

During the evaluation of ease of swallowing, the participants swallowed tablet samples in their usual manner, with unlimited access to room temperature spring water. The participants were not given specific instruction on the amount of water they should drink but advised to take the tablets as they would normally. The amount of water consumed for each tablet swallowed was recorded. This was calculated by subtracting the weight of the cup of water before and after taking the sample ($\rho_{H2O} \approx 1$ g/mL). For each sample, participants measured the

Table 1
Film coating systems (Opadry®) used in this study.

Abbreviation used	Film coat	Top coat	Main ingredients
Uncoated	–	–	–
EZ-EZ	Opadry EZ white	Opadry EZ clear	HPMC + polysaccharide + MCT*
EZ	Opadry EZ white	–	HPMC + polysaccharide + MCT*
Opadry	Opadry 03F white	–	HPMC

* MCT – medium chain triglycerides

Table 2
Film coating process conditions used to coat the placebo tablets (if roughness was observed in tablets, an adjustment in spray rate and pan speed was made to ensure tablets appear similar).

Parameter Film Coating	Batch 1 Opadry® White	Batch 2 Opadry EZ White	Batch 3 Opadry EZ White	Opadry EZ Clear top coat
Solids (% w/w)	15	15	15	8
Inlet Temperature (°C)	50	50	50	50
Bed temperature (°C) - actual	44.6	44.8	46.2	45.5
Exhaust temperature (°C)	43.3	44.7	44.0	42.2
Pan speed (rpm)	2.0–4.0	3.0–4.0	3.0–3.5	3.0–4.0
Atomizing pressure (bar)	2.5	3.0	3.0	3.0
Spray rate (g/min)	24	16	17	21
Weight gain (%)	3	3	3	1
Batch size (kg)	8.3	8.3	8.3	8.3

time taken to swallow each tablet using stopwatches. The time taken to swallow each tablet was measured by each participant from the moment the tablet was put into mouth until the perception of complete swallowing. The ease of swallowing was assessed by each participant using a 100 mm visual analogue scale (VAS) as shown in Fig. 1 (the assessment form is available in Appendix B). Additionally, incidents of tablet arrest in the mouth or throat were recorded. After swallowing of all four samples, participants ranked the tablets on an ordinal scale of 1–4 (score 1 corresponding to the easiest to swallow, score 4 to the hardest to swallow), ties were not allowed. Then participants indicated which tablets were acceptable as a yes/no option for each of the four tablets.

During the palatability part of the study, participants were instructed to hold the tablet in their mouth for minimum of 10 s and feel the tablet surface with their tongue and palate. After each sample, the mouthfeel was assessed using 3 VAS with the following anchor phrases: roughness ("Smooth" vs. "Rough"), adhesiveness ("Doesn't stick at all" vs. "Tablet is very sticky"), slipperiness ("Tablet slips easily" vs. "Stays in place"). Finally, overall palatability was assessed on a VAS ("Pleasant" vs. "Unpleasant") (the assessment form is available in Appendix C).

2.5. Data analysis

Statistical analysis was conducted to explore differences between samples, and the relationship between demographic data and participants' responses. The participants' marks on the VAS were transcribed into scores (from 0 to 100). Firstly, Friedman's ANOVA test (non-parametric test for related samples) was performed to screen for differences between samples ($p < 0.05$ was deemed significant). Further, Wilcoxon's signed rank test was used to determine differences between individual sample pairs. For a pairwise comparison of the 3 coated samples (excluding the uncoated tablet) $p < 0.0167$ level was used (derived from $p = 0.05$ divided by 3 combinations of pairs).

Furthermore, the participants were divided into two groups, ≤54 years and ≥ 55 years, to analyse the effect of age. Pearson Chi^2 test was used to analyse demographic data ($p < 0.05$ was deemed significant). For comparison of VAS scores between different populations the Mann-Whitney *U* test was used (non-parametric test for independent samples), $p < 0.05$ was deemed significant. The probability of the tablet arrest in relation to the sample taken was evaluated as odds ratio (OR) with 95% confidence intervals (CI).

The relationship between acceptability of a sample and given VAS score was evaluated using the Mann-Whitney *U* test ($p < 0.05$ was deemed significant). Finally, Receiver Operating Characteristic (ROC) analysis was used to determine the cut off VAS value for each parameter that defined as acceptable product. Data analysis was undertaken with SPSS statistical software version 24 (IBM Corp.).

Table 3
Participant demographics.

Number of participants (n = 83)	Frequency	Percent [%]
Gender		
Male	34	41.0
Female	49	59.0
Age (years)		
< 24	10	12.0
25–34	13	15.7
35–44	11	13.3
45–54	7	8.4
55–64	10	12.0
> 65	32	38.6
Problems with swallowing tablets previously		
No	60	73.2
Yes	22	26.8
Missing*	1	
History of taking medicines		
None daily	34	41.5
Between 1 and 3 daily	32	39.0
4 or more daily	16	19.5
Missing*	1	

* Participant did not answer the question.

3. Results

3.1. Participant demographics

The study recruited 84 non-smoking, healthy adults between 18 and 75 years of age. All participants finished both parts of the study. One subject was excluded from data analysis as they did not adhere to the study protocol (i.e. did not undertake palate cleansing between samples) and generated multiple outliers (defined as values > 1.5x interquartile value). Data from a total of 83 participants was analysed, 49 of them (59.0%) were female (Table 3). Participants over 55 years old accounted for the 51% of the study population. The number of medications taken daily was found to be age-related ($\chi 2$ (2) = 11.899, $p < 0.01$). Sixteen (19.5%) participants reported taking four or more medicines daily, with a majority of them being over 55 years old.

3.2. Ease of swallowing assessment

Prior to subsequent analysis of data, it was confirmed that the order of taking tablets did not influence the VAS score given by the participant (Friedman's ANOVA test, $p > 0.05$). VAS data was not normally distributed (Shapiro-Wilk test, $p < 0.05$), therefore median values were compared. The VAS results showed that the uncoated tablet (median VAS: 66 mm) was more difficult to swallow than any of the coated tablets (median VAS: 85–87 mm), $\chi 2$ (3) = 52.545, $p < 0.001$ (Fig. 2). While the coated tablets were all similarly easier to swallow [$\chi 2$ (2) = 4.315, $p = 0.116$]. The rank of ease of swallowing placed

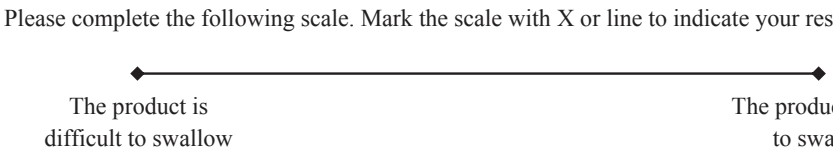

Fig. 1. Example of 100 mm unmarked Visual analogue scale (VAS).

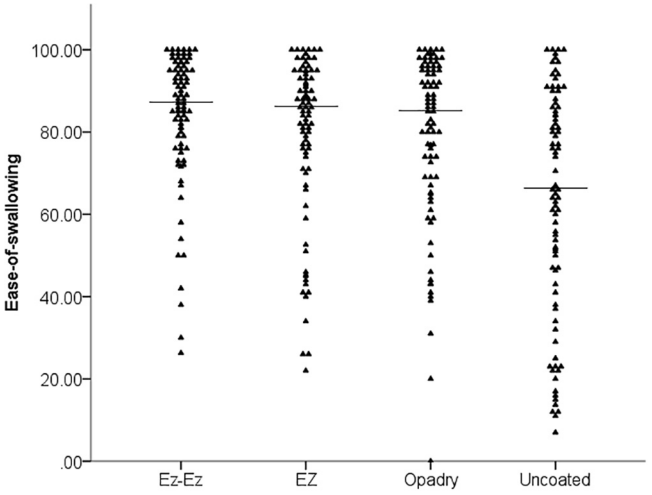

Fig. 2. Ease of swallowing VAS scores for all the samples; each ▲ represents one participant, line depicts median score (n = 83).

tablet samples in the following order: EZ-EZ > EZ > Opadry > Uncoated. Most participants ranked the coated tablet samples as their first choice, EZ-EZ (37.8%), EZ (25.6%), and Opadry (22%). Only 14.6% of participants ranked the uncoated tablet first, with the majority (64.6%) ranking it as the most difficult to swallow of all the tablets.

Participants drank between 0 mL and 125 mL of water to swallow each tablet. The median volume of water needed to swallow coated tablets was 28.8 mL, compared to 35.9 mL for the uncoated ones [$\chi 2$ (3) = 20.678, $p < 0.001$]. The time taken to swallow tablet samples ranged from 1 to 49 s with uncoated tablets taking longer to swallow than coated ones [$\chi 2$ (3) = 14.855$p < 0.01$].

With a fifth (20.5%) of the 332 tablets tested, participants reported tablet arrest i.e. the feeling that the tablet was stuck, either in their mouth or during the swallow. For the uncoated tablets 41% were reported, whereas the incidence for all coated tablets was only 14% (OR 0.229, CI 0.130–0.404). The incidence of tablet arrest inversely correlated with the ease of swallowing VAS and rank (U = 2119, $p < 0.001$, and U = 3111, $p < 0.001$, respectively). Moreover, in the event of tablet arrest more water and more time to swallow the tablet were necessary (Z (1) = -2.349, $p < 0.05$, and Z (1) = -4.160, $p < 0.001$, respectively). The occurrence of tablet arrest was neither age nor gender related ($\chi 2$ (1) = 0.127, p = 0.722, and $\chi 2$ (1) = 0.123, p = 0.726, respectively).

3.3. Mouthfeel and palatability assessment: Quantitative analysis of scales

Comparison of the median VAS scores for smoothness, stickiness, slipperiness and palatability of all samples are presented in Fig. 3. All four parameters showed the uncoated tablet to be statistically different from the coated tablets (Wilcoxon's test, $p < 0.01$). With the exception of slipperiness, participants were not able to perceive differences between the three coated tablets.

3.4. Demographic related aspects of ease of swallowing and palatability

3.4.1. History of issues with swallowing tablets

Over a quarter of the study population reported previous issues in swallowing tablets (n = 22/83). The reasons why participants reported issues in swallowing tablets previously are shown in Table 4. Those, who reported issues in tablet swallowing, rated the tablets on VAS as more difficult to swallow than those who did not declared any issues (U = 8633.5, $p < 0.05$).

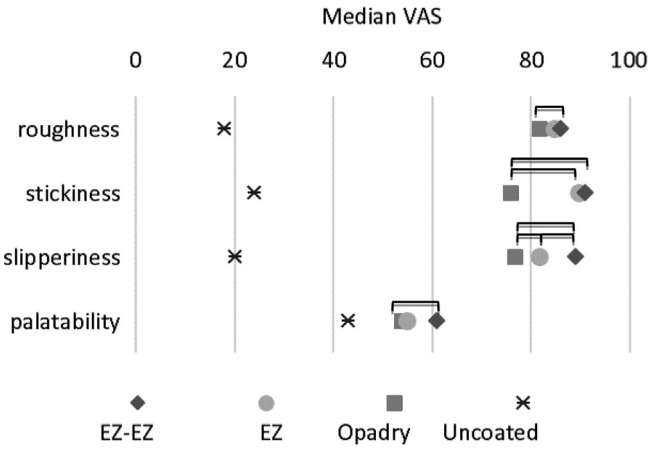

Fig. 3. Comparison of the four tablet samples in the mouthfeel test (score 0 means negative quality, 100 positive quality). Brackets indicate statistical significance ($p < 0.0167$).

Table 4
Problems reported with swallowing tablets.

	Frequency*	Percent of whole study population (n = 83)	Percent of those who stated that have problems with swallowing (n = 22)
Size of tablet	18	21.7	81.8
Taste of tablet	4	4.8	18.2
Texture of tablet	6	7.2	27.3
Aftertaste	3	3.6	13.6
Dry mouth	6	7.2	27.3
Other	1	1.2	4.5
Total	38		

* Multiple answers were possible.

3.4.2. Age

The occurrence of problems with swallowing tablets was found to be age related, with younger participants (≤54 years) reporting the difficulties more often than older participants (≥55 years) ($\chi 2$ (1) = 4.530, $p < 0.05$). Older participants took more time (median 7.5 s vs. 6 s), but less water to swallow the tablet (median 26.4 mL and 34.2 mL respectively) compared to the younger participants. Also, the instances of using no water at all were more common amongst the older than the younger population (10 cases (6.1%) vs. 4 cases (2.5%)).

The ability to distinguish between the samples differed between age groups. Both, young and old, could differentiate the coated from uncoated tablets. The younger group could distinguish between coated samples using scales of roughness, adhesiveness, slipperiness and palatability. However, the older population could only differentiate the roughness between EZ-EZ and EZ coated sample, where EZ-EZ samples had lower roughness.

3.4.3. Gender

The study found no correlation between gender and occurrence of problems with swallowing tablets ($\chi 2$ (1) = 0.004, p = 0.951). Neither, the time or water needed to take the tablet was gender related. Looking at the scores given on the VAS scale, there was no influence of gender, except for the palatability scale. Males tended to score the uncoated tablet as more pleasant than females did (median 50 vs. 36; U = 545, $p < 0.01$). In general, females were better able to differentiate the tablets than males. While females rated the uncoated tablet significantly less pleasant than coated ones (Wilcoxon's test, $p < 0.0167$), males gave similar palatability scores to all of the samples (Wilcoxon's test, $p > 0.0167$).

Table 5
Results of Mann-Whitney *U* test for the influence of the parameter on the acceptability, the sensitivity and specificity of the cut off (n = 83).

Parameter	Mann-Whitney U	P value	Cut off	Sensitivity	Specificity
Ease of swallowing (0 = difficult)	153.5	0.001	60	0.88	0.82
Water (mL)	214	0.018	40	0.64	0.64
Time (sec)	263.5	0.186	–	–	–
Rank (1 = best)	71.5	0.000	3	0.81	1
Roughness (0 = rough)	145	0.017	70	0.65	0.75
Stickiness (0 = sticky)	136	0.011	20	0.89	0.63
Slipperiness (0 = not slippery)	149	0.020	30	0.80	0.63
Palatability (0 = not pleasant)	258	0.522	–	–	–

3.5. Determinants of the acceptability

In contrast to the uncoated tablet (66%), almost all of the participants reported that the coated tablets would be acceptable to take on a daily basis (EZ-EZ 96%, EZ 93% and Opadry 95%). The score comparison of the acceptable and unacceptable tablets showed an association with the following parameters: ease of swallowing; amount of water taken with the tablet; rank; roughness; adhesiveness and slipperiness (Table 5). The VAS scores that best separated the parameters listed above into scores for acceptable vs non-acceptable tablets were calculated. For example, for ease of swallowing the cut off value of 60 mm divided acceptable and unacceptable tablets on the basis of VAS score given. Ease of swallowing was the parameter with the most sensitive and specific cut off (Table 5).

4. Discussion

Acceptability of solid oral dosage forms is driven by the ease of swallowing and palatability. Yet, there is limited understanding of the sensory parameters which have the largest impact on the acceptance of solid dosage forms. This study explored sensory attributes that relate to patient experience during the swallowing of a tablet. The participants' responses were collected on VAS, as it is known to be a sensitive tool to measure small differences in sensory perception. Furthermore, the acceptability of samples was compared with the VAS results, to define the acceptable and unacceptable qualities of tablets.

The ease of swallowing assessment showed that the addition of a coating onto a tablet enhances the ease of swallowing compared to an uncoated one. Also, the uncoated tablet was reported to get stuck more often and required more water to swallow, which may relate to its capacity to absorb liquid. The liquid penetration of the tablet is directly proportional to its porosity (Esteban et al., 2017). Thus the high porosity of uncoated tablet favours the effect of capillary ingress of the liquid. As a result, lubricant and air are removed from the tablet/mouth interface, which increases the risk of adhesion.

Additionally, the tablet cores contained insoluble excipients, hence the surface of the uncoated tablet is rough in contact with a wet surface. This results in greater friction associated with swallowing these tablets. In contrast, a layer of polymer coating reduces the amount of water absorbed, thereby maintaining lubrication and reducing friction. In addition, on hydration they form a slippery layer that further reduces friction. This hypothesis is supported by a study showing how coatings improved the ease of swallowing *in vitro*, where coated discs with lubricating properties needed a reduced force to be moved across *ex vivo* porcine oesophageal tissue (Smart et al., 2015). This explains the fact that the uncoated tablets are perceived to get stuck more often than coated tablets. Age was found to be an important factor in the process of taking tablets. The older population (≥55 years) reported difficulties with swallowing tablets less often; also they required less water to take the sample. As the older population consumes more medicines (Eurostat, 2017), it may be argued, that this is a function of experience and training with a range of solid oral dosage forms. Compared to the younger group, older participants had a longer duration of swallow. Published literature confirms that the passage of the tablet down the throat is longer in older adults (Pongpipatpaiboon et al., 2018). The results in this study may have been confounded by difficulties with using a timer or dexterity problems, rather than the slowness of swallowing itself. Despite the longer duration of the swallow, tablet arrest was not different between the older and younger populations.

The suggested volume of water taken with solid oral medicines is a full glass (Tamboli et al., 2010). In the literature, the typical amount consumed with medicines was reported as of 115 mL out of 150 mL provided (Fuchs, 2009). In this study, the median volume taken was 26.4 mL for coated and 34.2 mL for uncoated tablets. In all cases the total volume of water used to swallow tablets was less than generally recommended. The low volume consumed might be a consequence of the study set up. As the participants knew they would have to swallow a number of tablets one after another, so they may have tried to minimise their fluid intake.

Overall, the uncoated tablets in this study were regarded as inferior in terms of palatability to the coated ones. The VAS scores showed that the uncoated tablets had a rough, sticky, not slippery mouthfeel and unpleasant palatability. Whereas coated tablets showed the opposite sensation. The EZ-EZ tablet coating was superior across all parameters. The EZ-EZ coating was reported to be the most slippery and smooth, while EZ-EZ and EZ were less sticky than the Opadry coating. This was expected, as coatings based on HPMC polymers are known to have muco-adhesive properties (Washington, 2001). EZ-EZ and EZ coatings were designed to have low adhesion and high slipperiness by addition of polymer combinations and MCT which is oily, to the formulation. Thus, the differences observed in the slipperiness of the tablets were formulation dependent. In line with previous reports, addition of a glide-enhancing excipient (xanthan gum) into the coating, it enhances slipperiness *in vivo* (Mahdi and Maraie, 2015). The coated tablets were consistently ranked as more slippery than the uncoated one.

In this study, several parameters were associated with acceptability: ease of swallowing; amount of water taken with the tablet; rank order; roughness; adhesiveness and slipperiness. Thus, these parameters can be used as a measure of acceptability. A highly sensitive and specific measure is one that accurately separates acceptable from unacceptable tablets. Ease of swallowing and rank order were highly sensitive and specific measures of tablet acceptance. Stickiness and roughness were the mouthfeel attributes most strongly linked to tablet acceptance. The scaling with the use of cut offs provides an insight into what drives the acceptability. Some attributes were more critical than other. For example, the VAS cut off of 70 mm for roughness suggested that only samples which were undoubtedly smooth were acceptable. While a VAS cut off of 20 mm for stickiness indicates that only highly sticky tablets were unacceptable, and slightly sticky tablets were acceptable. Remarkably, palatability was not associated with acceptability in this study. The palatability is often related to the appreciation of taste. Yet the tablets were designed to be tasteless which may explain why palatability was less sensitive measure. This was also shown by the fact that the VAS scores on the palatability scale were clustered in the middle of the scale. Importantly, in a presence of bitter drug in a tablet the palatability should have significant impact on the acceptability.

5. Study limitations

There were a number of limitations associated with this study. First, the study recruited only participants self-assessed as healthy and excluded dysphagic patients or people with diagnosed swallowing difficulties. Second, the use of an untrained, non-expert panel has the potential to increase the variability of responses to the sensory attributes of tablets. All data were collected on a single visit, hence the repeatability of results within a single subject could not be determined. Finally, although visually the tablets were alike the uncoated tablet performed very differently to the coated tablets. Therefore, by comparing only coated tablets, a more differentiated picture of the preferred coatings might have been achieved.

6. Conclusions

This study aimed to investigate the ease of swallowing and oral sensory properties of coated tablets to determine how mouthfeel can improve acceptability. It was found that the oral sensory properties can be assessed by visual analogue scales. In particular, the presence of a tablet coating improved the ease of swallowing, mouthfeel and overall palatability. Uncoated tablets were perceived as rough, sticky and not slippery, while the coated tablets were predominantly slippery, smooth and pleasant. The extent of palatability improvement was film coating formulation dependent with the greatest improvement achieved with the most slippery coating (Opadry EZ white coated with clear Opadry EZ). Opadry coating was generally accepted, but had inferior mouthfeel scores compared to both Opadry EZ coating options.

In summary, sensory analysis based on VAS can improve understanding of the factors that influence overall acceptability of medicines. The oral sensory features, when related to acceptability using cut off values, could be used as references for the testing of new coatings in the future. Specifically, ease of swallowing and stickiness were found to be a highly sensitive and specific measure to predict tablet acceptance. Notably, palatability was not associated with acceptability, though this case is specific for placebo tablets, containing no substance with aversive taste.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contribution statements

Hannah Batchelor, Ali Rajabi-Siahboomi and Jason Teckoe conceived the idea presented. Hannah Batchelor and Justyna Hofmanova planned and undertook the practical work. Justyna Hofmanova undertook the analysis with statistical input from Sayeed Haque. Justyna Hofmanova and Hannah Batchelor wrote the manuscript with input from Julie Mason, Daniel To, Ali Rajabi-Siahboomi and Jason Teckoe. All authors provided critical feedback on the manuscript draft and revisions to shape the analysis and manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpharm.2019.03.046.

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Application of Slippery Film Coating for Easy Swallowing of Solid Dosage Forms

Daniel To, Jeff Gimbel, Jason Teckoe, Rita Steff enino and Ali Rajabi Siahboomi

Colorcon Inc., Harleysville, PA 19438, USA

AAPS
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Purpose

The US FDA and EMA recently issued industry guidance focused on reducing risk associated with medication errors and improving patient compliance. Recommendations are that varying color, shape, and size between dose strengths of a solid oral medication are useful tools to improve differentiation and minimize potential for errors. Additionally, visual differentiation of immediate and modified release dosage forms of the same drug is essential to ensure overall patient safety. Understanding the marketed product landscape for targeted therapeutic categories can help formulators better design a dosage form that is memorable and patient centric. Addition of a film coating on tablets is also clearly recommended in the guidance to improve patient compliance by enhancing the patient's ability to swallow tablets[1-3]. In this study a developmental film coating system has been evaluated to demonstrate wet slip behavior as an indication to provide improved swallowability.

Methods

The developmental film coating and commercially available Opadry® systems based on hypromellose or polyvinyl alcohol (PVA) (Colorcon, Inc. PA, USA) were coated onto 10 mm round biconvex and flat-faced placebo tablets in a fully perforated 12" pan (Labcoat I, O'Hara Technologies Inc., Ontario, CA). In addition, a clear top-coat of the developmental system was applied (up to 3% weight gain) onto the pigmented coated tablets. The gloss of the pigment coated and clear coated tablets were measured using a Surface Analysis System (Model 805A, Tricor Systems Inc. IL, USA).

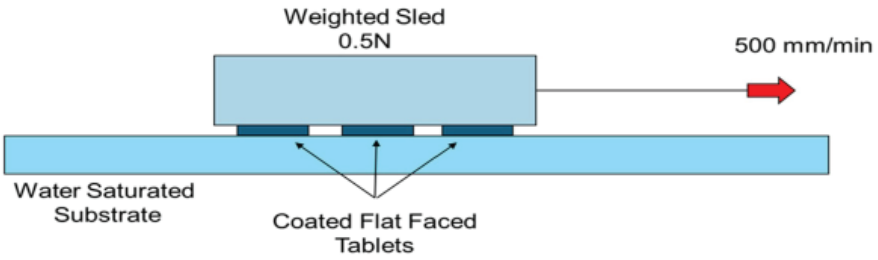
Table 1: Coating Conditions for Developmental and Opadry Film Coating Systems

	Pigmented			Clear
Parameter	Developmental	Opadry Hypromellose-based	Opadry PVA-based	Developmental
Solids content (%w/w)	20	15	20	8
Batch size (kg)	1			1
Spray rate (g/min)	8			8
Bed temperature (°C)	40			40
Airflow rate (m^3/hr) / (cfm)	212 / 125			212 / 125
Pan speed (rpm)	18			18
Atomizing air pressure (bar) /(psi)	1.4 / 20			1.4 / 20
Pattern air pressure (bar) / (psi)	1.4 / 20			1.4 / 20

Wet slip behavior characterization

An in-house method was developed to determine the wet slip behavior of the coated tablets. Three tablets weighted with a 0.5N normal force were pulled across a water saturated substrate at 500 mm/min (Figure 1) using an Instron tensile tester (Model 5542, Instron, MA, USA). The force profile required to drag the tablets was used to determine the static and dynamic friction coefficients. The static friction coefficient is the ratio between the force required to initiate tablet movement and the normal force, while the dynamic friction coefficient is the ratio between the average force during tablet movement and the normal force. The mean and standard deviation of the static and dynamic friction values are reported (n=5).

Figure 1: Schematic of Slip Testing Setup



Results

Coated Tablet Appearance

Tablets coated with the hypromellose-based, PVA-based and developmental pigmented film coating systems had surface gloss ranging between 65 – 80 GU (Figure 2). Application of a 1% weight gain of the developmental clear top-coat significantly improved the appearance of the coated tablets and increased the gloss to ≥115 GU, regardless of which pigmented coating was used. The gloss enhancement conferred by the clear coating was confirmed by the tablet images shown in Figure 3, which indicates that the tablets have a more elegant appearance with the clear coating. It has previously been shown that high gloss tablets are preferred and perceived as easier to swallow by patients, potentially improving patient compliance and medication adherence.[4]

Figure 2: Surface Gloss of Coated Tablets with and without Developmental Clear Top-Coat

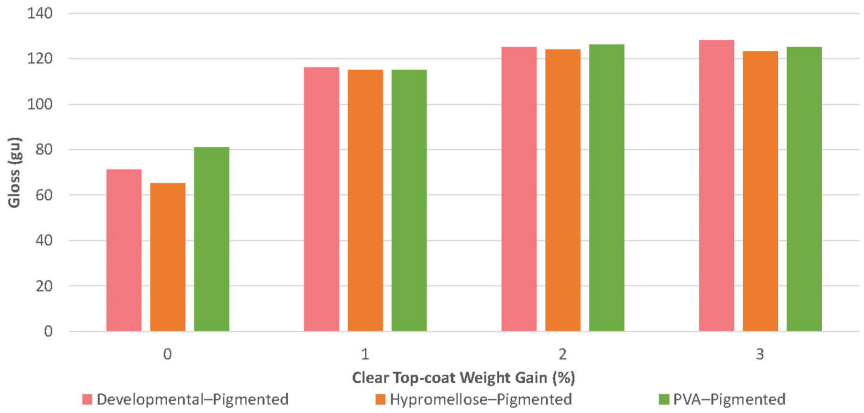
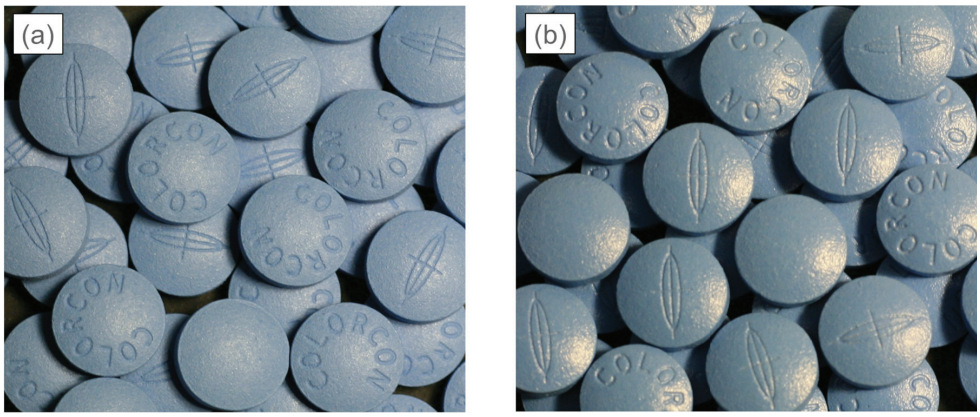


Figure 3: Developmental Pigmented Film Coated Tablets (a) with and (b) without Developmental Clear Top-Coat



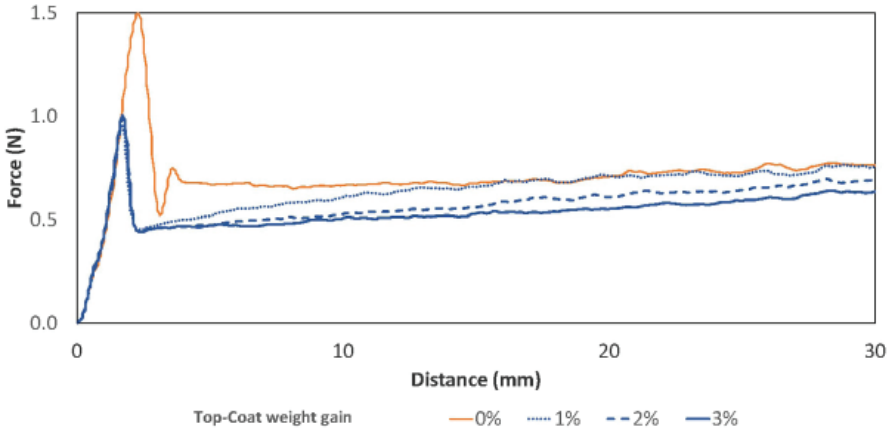
Wet Slip Test Force Profile

Typical force profiles for tablets coated with hypromellose-based, PVA-based and developmental pigmented film coating with and without the developmental clear film coating top-coat are shown in Figure 4a-c. The hypromellose and PVA coated tablets, without top-coat, showed a large spike of force required to initiate movement, indicating strong adhesion to the wetted surface. This was followed by a high dragging resistance force while moving at constant velocity. In contrast, the developmental pigmented system had a much lower initial and dragging force profile to move the coated tablet, suggesting enhanced slipperiness.

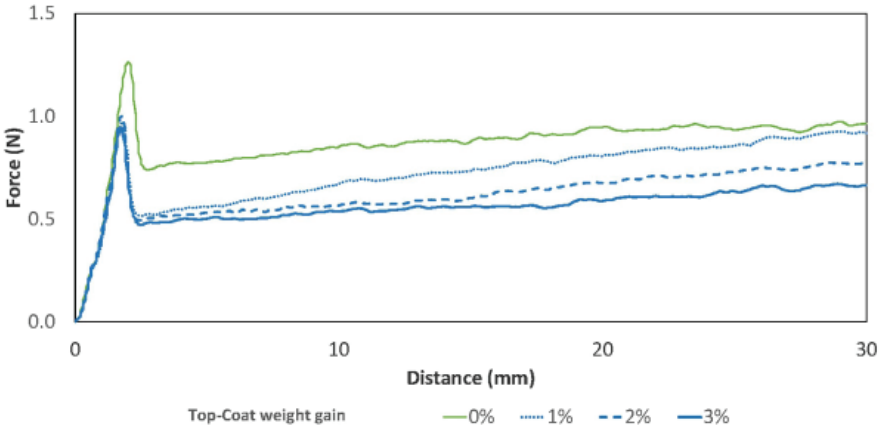
The additional application of the clear developmental film coating significantly lowered the force profile to drag the tablets, suggesting it imparts enhanced slip when wet. All weight gains of the clear developmental film coating significantly reduced the initial spike in force. The resistance force was initially reduced with a 1% weight gain. However, its influence began to decrease as the film coating dissolved. Increasing the coating to 2 or 3% continued to enhance slip throughout the duration of the test. The initial spike and resistance force of the developmental pigmented film coating was not significantly impacted by the presence of the developmental clear film coating system.

Figure 4: Force Profile of Dragging (a) Opadry - Hypromellose, (b) Opadry - PVA, and (c) Developmental Pigmented Coated Tablets with the Developmental Clear Top-Coat at 0-3% Weight Gain (n=5)

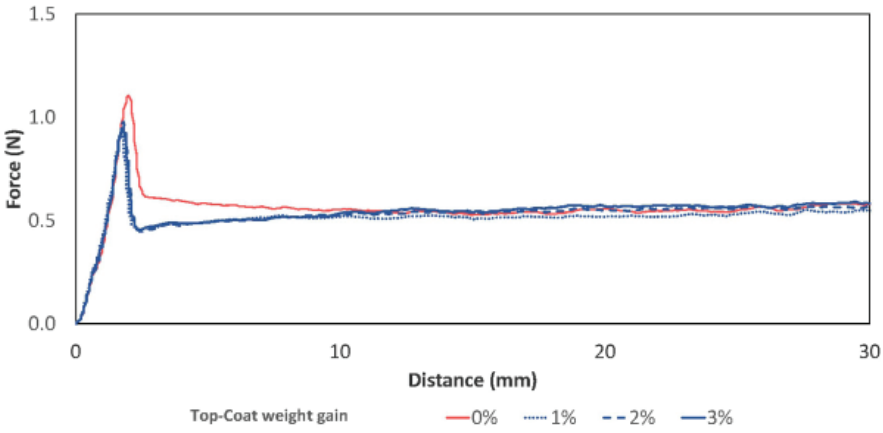
(a) Opadry - Hypromellose



(b) Opadry - PVA



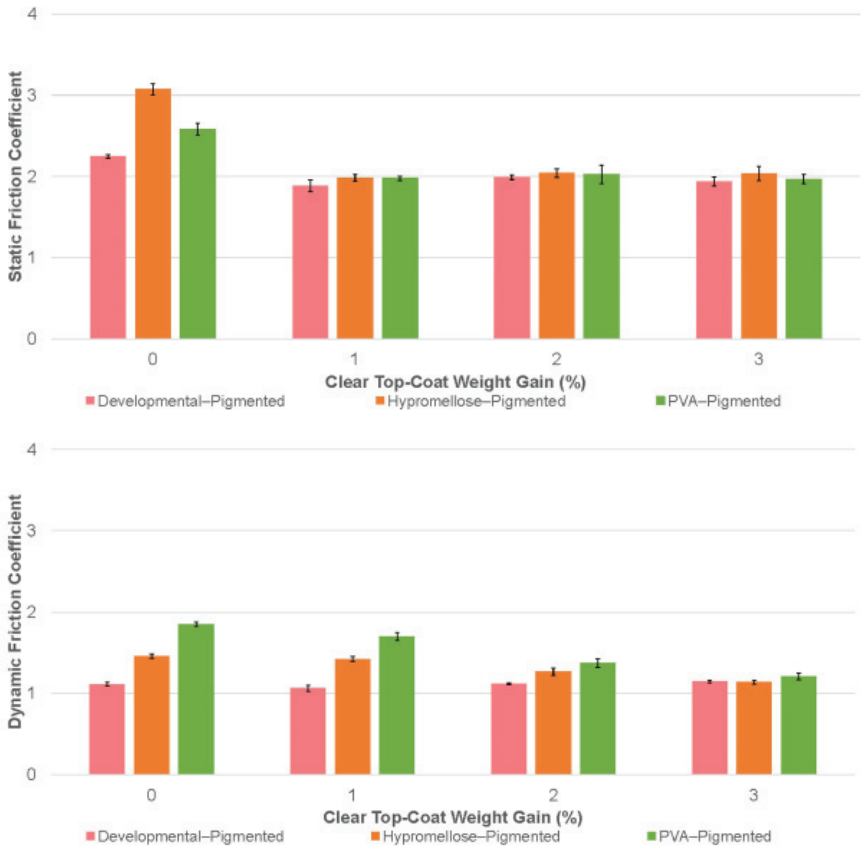
(c) Developmental Pigmented



Static and Dynamic Friction

The static and dynamic friction coefficients of the pigmented film coatings, with and without the developmental clear top-coat, are shown in Figure 5. The developmental pigmented film coating resulted in static and dynamic friction coeffi cients of 2.25 ± 0.02 and 1.11 ± 0.02, which are significantly lower than for hypromellose (3.07 ± 0.07 and 1.46 ± 0.03) and PVA-based coatings (2.58 ± 0.07 and 1.85 ± 0.03), suggesting enhanced wet slip behavior. Applying a 2-3% weight gain of the clear top-coat over hypromellose and PVA-based coatings was sufficient to decrease the static and dynamic friction coefficients by up to 33%, and provided comparable slip behavior to the developmental pigmented system, regardless of which pigmented coating was used.

Figure 5: (a) Static and (b) Dynamic Friction Coefficients for the Developmental Pigmented, Hypromellose and PVA-based Film Coatings with and without the Developmental Clear Top-coat (n=5)



Conclusions

The clear and pigmented developmental film coatings demonstrated exceptional wet slip behavior. Application of the developmental clear coating imparted excellent wet slip behavior to both the hypromellose and PVA-based coated tablets, while also improving the glossy appearance. Enhancing slip provides a way to improve tablet swallowability and enhance patient compliance.

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For more information, contact your Colorcon representative or call:

North America	Europe/Middle East/Africa	Latin America	India	China
+1-215-699-7733	+44-(0)-1322-293000	+54-1-5556-7700	+91-832-672373	+86-21-61982300

AN EASY PILL TO SWALLOW

In this article, Kelly Boyer, Vice-President, Film Coating, and Ali Rajabi-Siahboomi, PhD, Chief Scientific Officer, both of Colorcon, explore the role of different tablet coating materials in improving the patient experience and adherence to prescription regimens.

Around four in 10 adults report difficulty in swallowing tablets.[1] Recent guidance documents published by the US FDA and the EMA recognise that size, shape and coating are all contributory factors in the swallowing process and can impact adherence to prescription regimens.[2]

If a person has trouble swallowing, they may delay taking a tablet, skip a dose or discontinue the medication. Any of these actions can pose a serious health threat and, in the case of antibiotics, may contribute to antimicrobial resistance. Poor swallowability also leads to unnecessary medical costs and lost revenue for the drug manufacturer. Medical costs associated with skipping or discontinuing a medication are estimated at US$269 billion (£215 billion) in the US alone.[3]

Colorcon, a leader in the development and supply of specialty excipients, is incorporating the results of recent patient studies on swallowability to reinforce the benefits of tablet coating. The company anticipates that this approach will support the pharmaceutical industry in the creation of products that overcome both the perceived and real problems associated with swallowability, for all ages, mitigating adverse events such as pain, gagging and choking, whilst also providing a means of clear drug product differentiation.

> "Perception of medicines and a willingness to take tablets may be as important as physical difficulties in swallowing or dysphagia."

FACTORS THAT AFFECT SWALLOWABILITY

Perception of medicines and a willingness to take tablets may be as important as physical difficulties in swallowing or dysphagia. If the medicine is crucial to the health and well-being of the patient, they will be much more likely to take it. If the medication is discretionary and taken only to support lifestyle or general health, the patient may choose to skip a dose or stop taking the tablets altogether.

A patient's experience and ability to swallow medications may be impacted by age and whether they have underlying health issues such as stroke, Parkinson's disease or other neurological disorders that can lead to dysphagia. In the case of children, the elderly and psychiatric patients, their physiological and cognitive responses may be different from those of the general population.

There are essentially four phases of swallowing, the first two of which are the most important when it comes to the patient deciding to take the dose. Firstly, factors around the appearance of the tablet are important. If the visual perception of the tablet is large and rough, it will be perceived as difficult to swallow and the patient will be less likely to put it in their mouth. Next is how the tablet feels in the mouth/on the tongue – does it have an unpleasant taste, what is the texture like? The last two phases of swallowing revolve around avoiding choking and the tablet sticking in the oesophagus.

Each of these phases constitutes the patient's perception of whether a tablet is easy or hard to swallow. In all cases, taking water with the tablet is important

Kelly Boyer
Vice-President, Film Coating
E: kboyer@colorcon.com

Dr Ali Rajabi-Siahboomi
Chief Scientific Officer
E: asiahboomi@colorcon.com

Colorcon, Inc
275 Ruth Road
Harleysville
PA 19438
United States

www.colorcon.com

"Tablet weight, surface area, disintegration time and propensity for swelling should all be considered when designing products."

as this provides lubrication to improve transit times to the stomach and aids the disintegration process of the tablet itself.

REGULATORY GUIDANCE

In the past few years, both the FDA and the EMA have issued guidance encouraging pharmaceutical companies to design products that promote patient compliance and reduce medication errors. In practice, this means tablets should be of an appropriate size and shape to enhance swallowability and palatability of the drug. Tablet weight, surface area, disintegration time and propensity for swelling should all be considered when designing products.

Regulatory agencies around the world have acknowledged the advantages of film coatings applied to tablets and multiparticulate dosage forms. Benefits include:

- Easing swallowability by increasing mobility compared with an uncoated tablet of the same size and shape
- Improving the palatability of tablets by masking unpleasant tastes and odours
- Improving the aesthetic appeal of tablets
- Achieving the desired immediate- or modified-release profile
- Allowing easy identification, thereby minimising the risk of medication errors
- Enhancing the performance of the drug, protecting it from the environment, reducing friability and dusting issues, and ensuring better stability of the overall formulations.

SAFETY BY DESIGN

As the number and variety of medicines available increases and people are living longer, many patients are taking multiple medications and supplements. Pharmaceutical companies recognise that their products must meet the needs of target populations. While managing taste, smell and palatability are especially important for paediatric formulations, in the case of elderly patients it is crucial to support safe swallowing and reduce the risk of choking.

Focusing on the specific needs of patients ensures 'safety by design' and has an impact on a drug's success in the marketplace. This may include formulating drugs with extended-release profiles to reduce dosing frequency or using combination drugs. However, this approach can lead to larger tablets, which can negatively impact the ability to swallow.

Colorcon has conducted research into swallowability in order to improve the patient experience and safety. Studies have considered the impact of tablet size, weight, shape, surface area, disintegration time, palatability and propensity for swelling. Recent research focused on the development and application of film coatings to provide enhanced formulations that can positively impact the swallowing experience for patients.

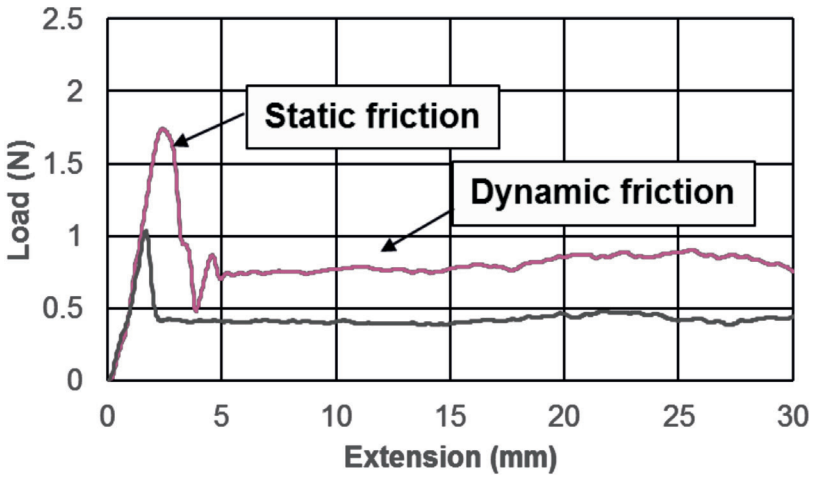

Figure 1: *In vitro* measurement of slip behaviour. Red line: hydroxypropyl methycellulose (HPMC)-based film coating. Black line: developmental slippery coating.

"In the case of oral dosage forms, the frictional interaction between surfaces and how fluids can act as a lubricant are important."

SWALLOWABILITY AND UNDERSTANDING SLIP

Tribology is the field of science that describes how surfaces interact with each other at a microscopic scale. In the case of oral dosage forms, the frictional interaction between surfaces and how fluids can act as a lubricant are important. Mixed lubrication is where there is still some physical contact between the surfaces, but a liquid is helping to reduce the overall friction. Hydrodynamic lubrication is achieved by increasing the amount of liquid between the surfaces, so they are separated and glide over each other more easily, with minimal friction.

Uncoated tablets can take 10 minutes or longer to move from the mouth to the stomach. Early research used gamma scintigraphy to measure the influence of film coatings on reducing transit times and demonstrated that the most effective coatings can reduce transit times to around 20–30 seconds.[4]

To investigate the incorporation of hydrophilic polymers into film coatings to lubricate the tablet surface when wet – either by contact with saliva or through taking a glass of water with the tablet – Colorcon developed a single test to characterise how different coating materials behave and to rank their slip performance. Slip was determined by measuring the force necessary to move tablets held in a weighted sled across a wet surface. The force necessary to start the sled moving (static friction) and the load necessary to keep the sled in motion (dynamic friction) were measured.

Using this test, different materials and film coating formulations were evaluated to identify good slip behaviour. The red line in Figure 1 represents a traditional hydroxypropyl methycellulose (HPMC)-based film coating, while the black line represents a developmental slippery coating, later launched as Opadry EZ, easy-swallow coating. Both the static friction and dynamic friction of the developmental coating are significantly lower than the traditional coating, indicating enhanced slip.

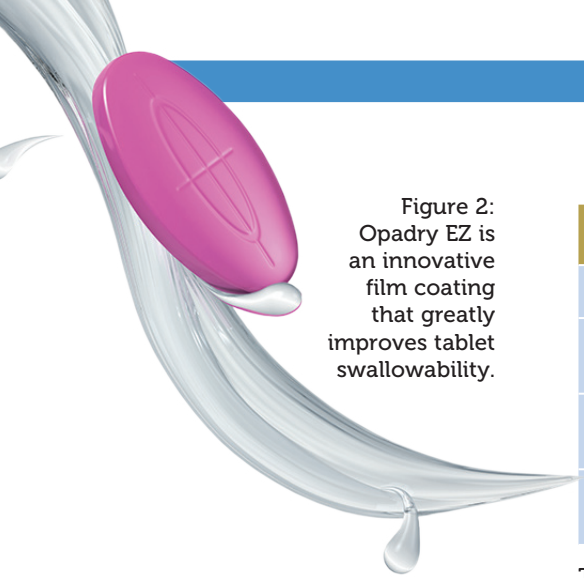

Figure 2: Opadry EZ is an innovative film coating that greatly improves tablet swallowability.

	Tablet specification	Short name
1	Uncoated placebo tablet	Uncoated
2	Opadry (Complete Film Coating System) 03F white coated placebo tablet	Opadry
3	Opadry EZ (Easy Swallow Film Coating System) white coated placebo tablet	EZ
4	Opadry EZ-EZ (Easy Swallow Film Coating System) white and clear top-coated placebo tablet	EZ-EZ

Table 1: Four variations of tablets used in the study.

As a result of this work, Opadry EZ easy swallow film coating was launched in February 2018. This innovative film coating greatly improves the swallowability of any tablet to which the coating is applied (Figure 2). Once wet, the slip performance is enhanced, significantly reducing the probability of the tablet sticking in the throat or oesophagus.

HUMAN SWALLOWABILITY STUDY

To test whether the enhanced slip of Opadry EZ, as shown by this *in vitro* method, resulted in a better swallowing experience for patients, an investigation was carried out in association with the University of Birmingham in the UK.[5] The study involved 84 healthy volunteers with a wide age and gender distribution. A single centre crossover study was used to measure the mouthfeel and swallowing experience of four 19 mm placebo tablets, taken in randomised order. One tablet was uncoated and the other three were coated as detailed in Table 1. Each participant was given four tablets in a randomised order.

Participants were asked to score the mouthfeel after holding the tablet in their mouth for 10 seconds based on the following parameters: smoothness, stickiness, slipperiness and palatability, using visual analogue scales (VAS). They were asked to rank the tablets in order of preference for ease of swallowing. The time taken to swallow the tablet and the volume of water used to aid swallowing were also recorded.

When the tablets were ranked in order of preference based on overall swallowing experience, the favoured sample was Opadry EZ-EZ, which was the first choice for 37.8% of participants (Figure 3). The tablet finish that was preferred by volunteers was the Opadry EZ film coating, either pigmented or with additional top coat for extra gloss. This reportedly increased mobility during the swallowing process.

The slipperiness of the tablet was found to be the best predictor of the ease of swallowing. VAS results for slipperiness were converted to a numerical score (Figure 4). Most participants gave the uncoated tablet a low score, indicating that the tablet stayed in place or stuck in the mouth. The Opadry EZ tablets had a higher proportion of people reporting high levels of slipperiness, with EZ-EZ showing the highest number of participants scoring easy slip.

In addition, participants provided three words to describe their experience of swallowing each of the tablets in order to explore their perception of the tablet in their mouth. The results are shown in Figure 5 using word clouds – responses with the highest occurrence appearing in large font and those with only a few occurrences in small or very small font. Colour is used to differentiate, with orange words depicting undesirable characteristics and green showing desirable characteristics.

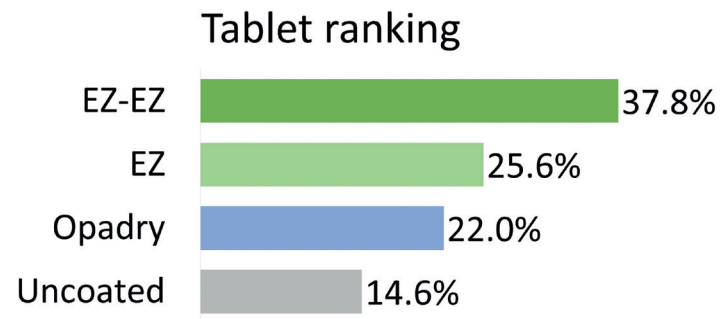

Figure 3: Study participant preference ranking of tablets.

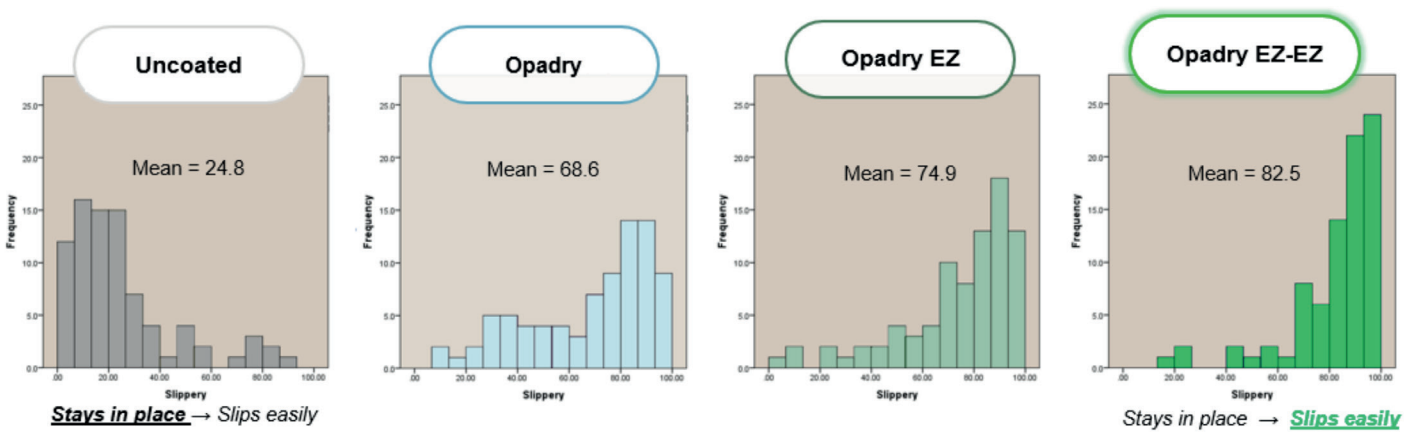

Figure 4: Scores of slipperiness versus frequency of score used.

Figure 5: Positive patient experience with Opadry EZ-EZ.

The results show that coated tablets are preferred to uncoated and demonstrate differentiated performance for swallowability depending on coating type. The Opadry EZ-EZ coating is preferred for mouthfeel, palatability and overall tablet acceptance, thereby providing the most positive patient experience.

The ability to detect differences in tablet coatings was influenced by age and gender, with younger females showing the greatest ability to distinguish between the samples. Although the study did not include any children or geriatric volunteers, it is intended that the findings will be used in future studies to understand how the work translates into these patient populations.

BENEFITS FOR PATIENTS

Compared with other formulations, the slip provided by the Opadry EZ-EZ tablet coating, once wet, significantly reduces the probability of sticking in the throat or oesophagus during the swallowing process. The improved tablet flow, combined with a glossy finish, also encourages better patient adherence and consumer appeal. Adopting this approach to tablet design supports the pharmaceutical industry to create products that satisfy both the perception and reality of ease of swallowing for all ages, mitigating adverse events such as pain, gagging and choking – and allowing clear differentiation between drugs.

ABOUT THE COMPANY

Colorcon is a world leader in the development, supply and technical support of formulated film-coating systems, modified-release technologies and functional excipients for the pharmaceutical and nutritional industries. Its products and technologies are complemented by value-added services, supporting all phases of solid dose design, development, and manufacture.

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ABOUT THE AUTHORS

Kelly Boyer is Vice-President, Film Coatings at Colorcon, where she heads the Global Business Development team responsible for the design, supply and technical support of formulated film coating systems for the pharmaceutical and nutritional markets. Ms Boyer has a degree in Chemical Engineering and over 30 years of experience in delivering innovative technology solutions around the world.

Ali Rajabi-Siahboomi is Vice-President and Chief Scientific Officer at Colorcon in the US. He obtained a bachelor's and a doctorate degree in pharmacy from University of Nottingham (UK). Dr Rajabi-Siahboomi has been with Colorcon for 20 years after a successful academic career in the UK. His main research interest and experiences are in the areas of solid dosage pharmaceutics, technology, and drug release modulation. He has published extensively in the field of oral drug delivery systems and is a regular contributor to pharmaceutical industry events around the world.