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Review Article

Fancy Colours and Shapes in Pharmaceuticals: A Comprehensive Review

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Abstract

Medications come in a wide variety of colors and shapes, which are often overlooked as simply being for looks. The visual design of pharmaceuticals, particularly the use of different vibrant colors and shapes, is essential for ensuring that patients adhere to their medication regimen, distinguishing one brand from another, and influencing how effective people believe the medications to be. The main purpose of using bright colors and unique shapes is to give pharmaceutical dosage forms a distinct appearance. Various pharmaceutical preparations, such as tablets, tablet coatings, hard and soft gelatin capsules, liquid oral medications, dental pastes, ointments, and creams, among others, require specific coloring and shapes. The examination of colors' impact on patient adherence, psychological effects, and brand identity is accompanied by the importance of pill shape for ease of swallowing, dosage accuracy, and product recognition. Technological advancements, including 3D printing (3DP), are broadening the scope for innovative drug designs. Regulatory considerations by organizations such as the FDA (Food and Drug Administration) and EMA (European Medicines Agency) guarantee that these designs maintain safety and efficacy while addressing challenges and limitations. This review article initially highlighted on the comprehensive overview of the basic of fancy colour and shapes in pharmaceuticals, their emerging application including their importance and significance in the pharmaceutical drug design. Intermediately describes the technology advancements regarding the design of medicines. Lastly well explained the regulatory aspects related to the colours and shapes for the drug design with their several future prospects.

Keywords: Shapes; Colour; Pharmaceuticals; Whimsy; Drug Design; Formulations; Medications; Drug Diversity; Developments; Pharmacy

Abbreviations

3DP: 3-D Printing; FDA: Food and Drug Administration; EMA: European Medicines Agency; GMP: Good manufacturing Practice; QA: Quality assurance; QC: Quality control; DD: Drug delivery; NDDs: Novel drug delivery systems, BA: Bioavailability; ODTs: Orally disintegrating tablets; TDDs: Targeted Drug Delivery; NPs: Nanoparticles.

Introduction

The design of pharmaceuticals transcends mere functionality, integrating a myriad of aesthetic elements that significantly impact their overall acceptance and effectiveness. Among these elements, the use of various colors and shapes stands out as a crucial factor. These visual characteristics are not merely about branding or making medications more visually appealing; they play a fundamental role in patient compliance, the differentiation of products in a competitive market, and the perceived efficacy of the drugs [1]. Historically, the appearance of medications was given little consideration, with most being dispensed in the form of simple powders or liquids. However, as the pharmaceutical industry evolved, the importance of aesthetic design became more evident. The transition to coated tablets and capsules marked a significant shift, highlighting how colors and shapes could influence patient behavior and treatment outcomes [2-4].

The colors in pharmaceuticals serve several critical functions. They help patients distinguish between different medications, thus reducing the risk of confusion and improving adherence to prescribed regimens. This is particularly important for elderly patients and those managing multiple medications [5]. Additionally, colors can evoke specific psychological responses; for example, blue and green hues are often associated with calmness and tranquility, whereas vibrant colors like red and yellow can signify strength and potency. Similarly, the shape of a pill is a vital consideration in drug design. Patient-friendly shapes can make tablets easier to swallow, which is especially beneficial for children and the elderly. The distinctive shapes can aid in brand recognition and help prevent counterfeiting, ensuring that patients receive the correct medication [6-9].

Fancy colors

The use of fancy colors in pharmaceuticals encompasses a range of hues and shades designed to enhance the visual appeal, functionality, and efficacy of medications. These colors are strategically selected to serve various purposes, from improving patient compliance to differentiating brands.

Types of colors in pharmaceuticals

The use of fancy colors in pharmaceuticals goes beyond mere aesthetic appeal, serving several essential functions that enhance patient experience and medication efficacy [10-12]. The different types of color in pharmaceuticals mentioned in the given Table 1 as below following.

Natural colors, sourced from plants and other natural origins, are commonly utilized in health-conscious and natural product ranges. These colors are popular for their perceived safety and natural roots, attracting consumers who prioritize natural components in their healthcare products. Conversely, synthetic colors are artificially produced chemicals that offer a broad spectrum of vibrant and consistent shades. They are cost-effective and stable, but their usage is closely monitored due to potential allergic reactions, ensuring compliance with safety regulations. Lakes and dyes offer flexibility in pharmaceutical applications. Lakes are insoluble in water and are typically found in oil-based products and coatings, while dyes are water-soluble and are used in liquid medications and coloring tablets [17-19]. This versatility allows for precise application depending on the formulation requirements of the medication. Specialty colors, such as metallic and iridescent pigments, enhance the visual appeal of pharmaceuticals and create a premium look. These colors are often used for brand differentiation and marketing purposes, helping products stand out in a competitive market [19-22].

Table 1: The list of fancy colors in pharmaceuticals including, their description [13-16].

Colors Type	Example	Description	Common Uses
Natural Colors			
Chlorophyll	Green	Derived from plants; provides a green hue	Natural supplements, herbal medications
Curcumin	Yellow	Extracted from turmeric; offers a bright yellow color	Anti-inflammatory drugs, dietary supplements
Beetroot Powder	Red	Sourced from beetroot; gives a natural red shade	Natural product lines, multivitamins
Synthetic Colors			
Tartrazine	Yellow	Synthetic dye; bright yellow	Liquid medications, chewable tablets
Allura Red	Red	Synthetic dye; vibrant red	Cough syrups, coated tablets
Brilliant Blue	Blue	Synthetic dye; intense blue	Capsules, gel-based medications
Lakes and Dyes			
FD&C Red No. 40	Red (both dye and lake)	Water-soluble dye; lake form is oil-dispersible	Tablets, soft gels, liquid medications
FD&C Yellow No. 5	Yellow (both dye and lake)	Water-soluble dye; lake form for coatings	Capsules, syrups, coatings
FD&C Blue No. 1	Blue (both dye and lake)	Water-soluble dye; stable and bright blue	Tablets, liquids, coating agents
Specialty Colors			
Titanium Dioxide	White	Mineral-based; used for opacity and white color	Tablet coatings, sunscreen lotions
Mica-Based Pearlescent Pigments	Metallic Colors	Provide a metallic sheen; mica coated with titanium dioxide or iron oxides	Premium tablets, brand differentiation
Iridescent Pigments	Color-Changing	Change color based on the angle of light	High-end medications, for marketing purposes

Fancy shapes

The use of fancy shapes in pharmaceuticals involves designing pills and tablets in various forms that enhance their functionality, appeal, and effectiveness. These shapes serve multiple purposes, including improving patient compliance, ensuring accurate dosing, and differentiating brands [23,24]. The different types, significance and examples of fancy shapes in pharmaceuticals mentioned in the Table 2 as below description.

These fancy shapes in pharmaceuticals not only improve patient compliance and therapeutic outcomes but also contribute to brand identity and market differentiation. They leverage technological advancements to enhance drug delivery and patient experience [29,30].

Technological advancements have further expanded the possibilities for innovative pharmaceutical designs. The advent of 3DP technology, for example, allows for unprecedented precision in creating customized drug shapes and sizes, enhancing both functionality and patient experience. This technology also enables the development of complex drug release mechanisms, paving the way for more personalized and effective treatments. The incorporation

of aesthetic elements into pharmaceuticals must be balanced with stringent regulatory requirements. Regulatory bodies such as the FDA and EMA have established guidelines to ensure that the use of colors and shapes does not compromise the safety and efficacy of medications. Navigating these regulations is a critical aspect of pharmaceutical design [24-30].

This comprehensive review explores the multifaceted role of colors and shapes in pharmaceuticals. It examines their historical development, the impact on patient behavior, technological innovations, and regulatory considerations. Through the analysis of successful case studies and the identification of current challenges, this review aims to provide a thorough understanding of the importance and future directions of aesthetic design in the pharmaceutical industry.

Emerging applications of fancy colors and shapes

The emerging applications of fancy colors and shapes in pharmaceuticals are expanding the possibilities for medication design and patient interaction.

Importance of color in pharmaceuticals

The use of color in pharmaceuticals extends beyond aesthetics, playing a pivotal role in various aspects of medication management and patient care:

- **Patient safety and identification:** Colors aid in distinguishing between different medications, strengths, and dosage forms, thereby reducing the risk of medication errors. This is crucial in environments where multiple medications are administered concurrently. Using distinct colors for different medications, it becomes easier for patients, caregivers, and healthcare professionals to quickly identify and differentiate between drugs, reducing the risk of medication errors. Color-coding also aids visually impaired patients and helps ensure that the correct medication is taken at the appropriate dosage and time. Additionally, it enhances brand recognition and compliance, as patients are more likely to remember to take medications that are easily distinguishable by color.
- **Enhanced patient adherence:** Colors can influence patient behavior and adherence to prescribed regimens. Vibrant and distinct colors make medications more recognizable and memorable, encouraging patients to take them as directed.
- **Psychological impact:** Colors evoke psychological responses that can affect patient perception of medication efficacy and safety. For example, calming colors like blue and green may promote a sense of tranquility, whereas bold colors like red and yellow can imply strength or urgency. Color-coding can simplify complex medication schedules, making it easier for patients to remember when and how to take their medications. This visual differentiation reduces confusion, especially for those taking multiple medications, and can increase the likelihood that patients will adhere to their prescribed treatments, ultimately leading to better health outcomes.
- **Brand differentiation:** Pharmaceutical companies use color as a branding tool to distinguish their products in a competitive market. Consistent use of specific colors reinforces brand identity and fosters brand recognition among consumers.
- **Regulatory considerations:** Regulatory agencies, such as the FDA and EMA, provide guidelines on the use of colors in pharmaceuticals to ensure safety and efficacy. These guidelines govern the types of colorants that can be used and their permissible concentrations [30-33].

Significance of shape in pharmaceuticals

The shape of pharmaceuticals impacts various aspects of medication administration and patient experience:

- **Ease of Administration**: Patient-friendly shapes are crucial in simplifying the swallowing of dosage forms especially in pediatric and geriatric populations who unnecessarily have challenges with traditional tablets. But shape cannot be entirely evaluated without reference to size. The shape and size factors directly influence the swallowability, manipulation and patient adherence. Indicatively, the oval or capsule-shaped pills are easier to swallow than large round pills, but very large pills, regardless of shape, are likely to stimulate non-compliance. Mini-tablets and smaller capsules are being used

more to address this which is especially effective in the vulnerable groups since they offer the appropriate size coupled with optimised shapes that can be accepted better. This integration is to make sure that pharmaceuticals are not only aesthetically unique, but also useful and friendly to patients. Correlations of shape and size in designing dosage forms can be seen as a more holistic approach to balancing therapeutic effectiveness, ease of use, and brand identity and better patient outcomes and adherence.

- **Dosage Precision**: Certain shapes, such as scored tablets, allow for precise dosage adjustments. This is beneficial when titrating medication doses or when patients require customized dosing regimens.
- **Therapeutic Functionality**: Advanced shaping technologies, including 3DP, enable the design of tablets with specific geometries that optimize drug delivery and release profiles. This customization can improve therapeutic outcomes and patient compliance.
- **Brand Recognition**: Unique and branded shapes differentiate pharmaceutical products visually, contributing to brand identity and market competitiveness. Recognizable shapes enhance product recall and consumer preference.
- **Technological Innovation**: Shape design continues to evolve with technological advancements, facilitating the development of NDDs. Innovations in shape-related technologies contribute to the advancement of personalized medicine and patient-centric care [33-35].

The various significance of fancy shapes utilized in pharmaceuticals along with suitable dosage forms mentioned in the given Table 3 as below section.

Table 3: The significance of fancy shapes in the formulations of dosage form.

Shape	Significance	Suitable Dosage Form
Round	Easy to swallow, popular and familiar	Tablets, Lozenges
Oval/Elliptical	Easier to swallow, reduced risk of lodging in throat	Capsules, Softgels
Oblong/Rectangular	Can accommodate more active ingredients	Caplets, Extended-release tablets
Square	Less common, distinct identification	Chewable tablets, Mints
Triangular	Unique shape for differentiation	Chewable tablets, Gummies
Diamond	Aesthetic appeal, distinct identification	Tablets, Capsules
Hexagonal	Unique, easy to identify	Tablets, Suppositories
Cylindrical	Easy to insert or apply	Suppositories, Topical sticks
Teardrop	Ergonomic, easy to apply	Suppositories, Ear drops
Heart-shaped	Appealing, encourages adherence	Chewable tablets, Gummies
Star-shaped	Child-friendly, appealing	Chewable tablets, Gummies
Capsule-shaped	Easy to swallow, accommodates larger doses	Capsules, Softgels

In summary, both color and shape in pharmaceuticals serve critical roles beyond their visual appeal. They contribute to patient safety, adherence, therapeutic efficacy, and brand differentiation while adhering to regulatory standards and fostering technological innovation in drug delivery.

Technological advancements

Technological advancements have revolutionized the way fancy colors and shapes are utilized in pharmaceuticals, enhancing both the functionality and aesthetic appeal of medications. The various key advancements in the pharmaceuticals:

3D printing (3DP) technology

The 3DP technology utilized in the formulation of dosage form involving colors and various shapes in the pharmaceutical industries, the overview of formulations represented in the given Figure 1 as below followings.

Customization

3DP allows for the precise design and manufacturing of medications with intricate shapes and customized dosages. This capability is particularly beneficial for personalized medicine, where medications can be tailored to meet individual patient needs.

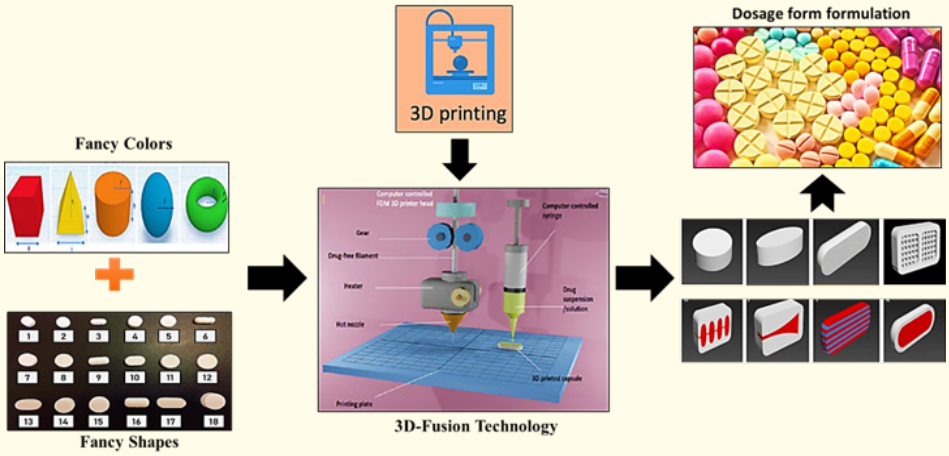

Figure 1: The representation of 3DP in formulation of dosage form in pharmaceutical industries.

Complex geometries

Pharmaceuticals can now be printed with complex geometries that optimize drug release profiles and improve therapeutic efficacy.

Patient-centric designs

This technology enables the creation of patient-centric designs, such as tablets that are easier to swallow or have enhanced dissolution properties [36].

Coating technologies

- **Controlled Release:** Advanced coating technologies provide precise control over drug release mechanisms, ensuring consistent therapeutic levels in the body.
- **Color Integration:** Coatings not only protect medications but also incorporate fancy colors for branding and patient identification purposes [37].

Nanotechnology

- **Improved Bioavailability (BA):** Nanotechnology enhances the BA of poorly soluble drugs by improving their solubility and absorption rates.
- **Targeted Drug Delivery (TDDs):** Nanoparticles (NPs) can be designed to deliver drugs to specific target sites in the body, reducing systemic side effects and enhancing therapeutic outcomes [38].

Smart packaging solutions

- **Interactive Features:** Smart packaging integrates technologies like RFID tags, QR codes, or color-changing indicators to enhance medication adherence and safety.
- **Temperature and Moisture Control:** Packaging materials can maintain medication stability by controlling temperature and moisture levels, extending shelf life and efficacy [39].

Color and shape are important in pharmaceutical design in the areas of coating technology, nanotechnology and smart packaging. Colors in the form of a coating not only make a brand identity and patient recognition but also facilitate the process of adherence, whereas shapes help produce coating uniformity and swallowability along with controlled or delayed release of drugs. Color in nanotechnology is used to indicate the stability of formulation and functionalization. The shape of the particle is of great importance in drug release, biodistribution, and cellular uptake; targeting and therapeutic efficacy can be improved using shape-engineered nanoparticles. Likewise, in intelligent packaging, color marks can be used to indicate the stability of the product and its exposure to inappropriate conditions, and the shape of the packages and dosage enhance the protection and storage of the product. Therefore, in addition to aesthetics, color and shape also have a direct connection to drug stability, delivery accuracy and precision, patient safety and treatment outcomes.

Digital manufacturing and quality control (QC)

- **Automation:** Digital manufacturing processes streamline production and ensure consistency in medication quality and shape.
- **Quality Assurance (QA):** Advanced analytics and quality control systems monitor every stage of production, from formulation to packaging, ensuring compliance with regulatory standards [40].

Innovative excipients

- **Functionality:** New excipients and formulation techniques improve the stability, solubility, and BA of medications, supporting the integration of fancy colors and shapes. These advanced excipients can improve drug performance, ensure consistent therapeutic effects, and allow for more sophisticated and appealing dosage forms, ultimately enhancing patient adherence and satisfaction.
- **Sustainability:** Efforts are underway to develop excipients that are sustainable and environmentally friendly, aligning with global sustainability goals. This includes sourcing raw materials responsibly, reducing carbon footprints during production, and ensuring that excipients are biodegradable or have minimal environmental impact. Sustainable excipients contribute to the overall effort to make the pharmaceutical industry more eco-conscious and responsible.

These technological advancements not only expand the possibilities for pharmaceutical design but also contribute to improved patient outcomes, enhanced medication adherence, and greater efficiency in drug delivery systems [38-42]. By leveraging these technologies, pharmaceutical companies can innovate and differentiate their products while meeting the evolving needs of healthcare professionals and patients alike.

Regulatory consideration

In the application of colors in pharmaceutical products, regulatory factors play a key role since the colors in the products are not applied merely to enhance the beauty of the product, but they also have other roles such as in the identification of the product by patients, its use by patients, and brand positioning. Regulatory bodies like the FDA (USA), EMA (Europe), and CDSCO (India) are very much strict on the dyes that may be used. Approved colorants only (e.g. FD&C dyes in the US, Schedule Q colors in India) may be used, and the safety of these must be determined by carrying out toxicological analyses. Colorants should be clearly stated as an excipient on the labels to allow patients with allergies, like those allergic to tartrazine make a better decision [43]. To maintain drug stability, efficacy and bioavailability, regulators also keep colors out of the way and discourage candy-like drug colouration in products used by children in order to discourage accidental swallowing. Some iron supplements are bright orange or red, some antihistamines are often made in pastel colors, etc., to help people identify the product.

With the case of shapes, the regulation provides that it makes them safer and easier to use without deceiving the patients. Shapes not only affect swallowability and compliance among the patients, but also the release profile of the controlled formulations. Regulators demand that the therapeutic performance is not affected in any way by the design of the tablet or capsule. Candy-like or toy-like shapes are also not used to reduce the chances of accidental ingestion particularly among children. The fact that the distinctive shapes are patented by the trademark and Pfizer has blue-diamond-shaped Viagra reveals that the branding value is obtained through its distinctiveness, but the regulators insist that generics should be safely differentiable. Popular ones are oval-shaped paracetamol pills so that they can be easily swallowed and chewable antacids in round, candy-like shapes, where there is a strong requirement of labeling. Therefore, the innovation and branding as well as patient safety in pharmaceuticals are balanced in terms of colors and shapes [44,45].

Conclusion and Future Perspective

The utilization of various vibrant fancy colors and their unique shapes in pharmaceutical products serves multiple purposes, such as improving patient adherence, ensuring safety, and setting brands apart. Both natural and synthetic colors help in creating recognizable visual identities while adhering to safety regulations. Shapes, whether traditional or 3DP, are designed to optimize drug delivery (DD) and patient acceptance. Together, these elements contribute to better medication adherence and therapeutic results. The incorporation of diverse colors and shapes in pharmaceuticals goes beyond aesthetics, playing a crucial role in patient compliance, brand recognition, and treatment effectiveness. With advancing technology, there are endless possibilities for innovative drug designs that can enhance the overall patient experience. It is important to strike a balance between these advancements and regulatory standards to prioritize the safety and efficacy of medications.

Future perspective

The several future perspectives discussed as below following discussion. Looking ahead, several trends and opportunities shape the future of fancy colors and shapes in pharmaceuticals represented in the given Figure 2 as below description.

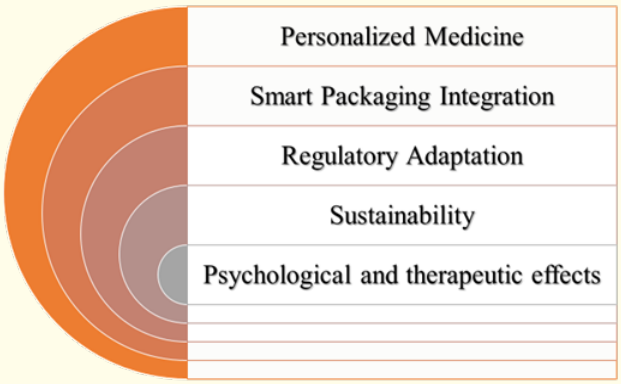

Figure 2: The several future perspectives for drug design and pharmaceuticals.

Personalized medicine

Advances in technology, such as 3DP and personalized formulations, will enable tailored medications that meet individual patient needs and preferences.

Smart packaging integration

Incorporating smart packaging technologies will enhance medication adherence through interactive features that support patient engagement and medication management.

Regulatory adaptation

Continued harmonization of global regulatory standards will streamline approval processes and ensure consistent safety and efficacy evaluations for innovative color and shape applications.

Sustainability

There is a growing emphasis on sustainable practices in pharmaceutical manufacturing, including the development of eco-friendly colorants and packaging materials.

Psychological and therapeutic effects

Future research will explore the psychological impact of colors on patient perception and treatment outcomes, optimizing therapeutic benefits.

The integration of fancy colors and shapes in pharmaceuticals not only meets aesthetic and marketing needs but also advances therapeutic effectiveness and patient-centered care.

Ethical Consideration

Not applicable.

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Conflict of Interest

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