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Chewable Gels as Nutraceutical Delivery Systems: A Comprehensive Review of Formulation, Bioavailability, And Health Implications

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ABSTRACT
Nutraceuticals, the convergence of nutrition and pharmaceuticals, offer a wide array of health benefits from enhancing overall well-being to managing specific conditions. Despite their potential, challenges in the effective delivery of nutraceuticals, such as poor solubility and unpredictable chemical properties, have prompted the exploration of innovative delivery systems. Chewable gels have emerged as a promising solution, providing convenient ingestion and improved bioavailability. Chewable gels not only enhance consumer compliance due to their palatability and ease of use but also offer precise dosing and potential health benefits. Looking forward, advancements such as nano emulsions and sustainable excipients could further enhance the efficacy of chewable gels, while 3D printing offers avenues for personalized options. This review comprehensively explores the formulation, evaluation, impact, and future perspectives of chewable gels in delivering nutraceuticals for improved health and wellness.
Keywords: *Bioavailability, chewable gels, Health, Nutraceuticals, stability.*

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INTRODUCTION

Nutraceuticals

Nutraceuticals are a fascinating intersection of nutrition and pharmaceuticals, offering a bridge between traditional dietary supplements and pharmaceutical interventions. These products are defined by their health benefits, ranging from improving overall health to preventing and managing specific conditions. They encompass a wide array of substances, including vitamins, minerals, herbs, and other natural compounds known for their positive impact on health [1].

Challenges in Nutraceutical Delivery

Despite their potential benefits, the effective delivery of nutraceuticals presents a significant challenge. The human body's complex digestive system can often break down these compounds before they are fully absorbed, reducing their efficacy. This challenge has led researchers to explore innovative delivery methods that enhance bioavailability and absorption. One promising solution lies in chewable gels, which offer a unique and attractive carrier for nutraceuticals [2]. Nutraceuticals face challenges due to insufficient water solubility, elevated melting points, and unpredictable chemical active ingredients. Innovative delivery systems are needed to make these compositions affordable [3]. Creative methods are needed to preserve integrity and benefits. Suspended nanocrystals could be used, but this leads to deteriorated stability, shelf life, and unpleasant odors. Advanced dosage forms, like Orodispersible tablets, fast-dissolving films, and easy-swallowing gels, are needed for older individuals and children[4].

The Emergence of Chewable Gels as a Promising Delivery System

Chewable gels have emerged as a popular and effective delivery vehicle for nutraceuticals, offering a delightful combination of convenience, taste, and efficacy. These gels are not only enjoyable to consume but also address challenges such as the need for easy ingestion, particularly for individuals who have difficulty swallowing pills[5]. By encapsulating nutraceuticals in a chewable gummy format, manufacturers can mask any unpleasant flavors or Odors, making them more appealing to a broader audience. Furthermore, the chewable nature of gel promotes prolonged contact with the oral mucosa, enhancing absorption and

bioavailability of the encapsulated nutraceuticals [6]. This makes chewable gummies an attractive option for delivering a wide range of beneficial compounds, from vitamins and minerals to herbal extracts, in a convenient and enjoyable manner [7].

FORMULATION STRATEGIES FOR CHEWABLE NUTRACEUTICAL GELS

Selection of Gelling Agents and Excipients

Chewable gels require careful selection of excipients and gelling agents, often using synthetic and natural polymers. Modifying formulation parameters can address nutraceutical issues, while adhering to quality, safety, and performance standards is crucial. Excipient functionality is influenced by the complex synthesis of active ingredients, and functionally equivalent excipients may not always be functionally equivalent [8].

Gelatin: Gelatin is a protein derived from collagen, often sourced from animal skin or bones. It serves as a primary gelling agent in chewable gel formulations, providing the characteristic chewy texture. Gelatin also helps chewable gels retain their shape and structure. However, it is not suitable for vegetarian or vegan products, leading to the use of alternative gelling agents like pectin [9].

Pectin: Pectin is a naturally occurring polysaccharide found in fruits, particularly apples and citrus fruits. It is a popular gelling agent in chewable gel manufacturing, especially for vegetarian or vegan formulations. Pectin creates a gel-like structure when combined with sugar and acid, giving gels their chewy texture. It is also known for its dietary Fiber properties and can contribute to the health profile of the chewable gel.[10]

Flavouring and Sensory Aspects

Sugar and Sugar Substitutes: Sugar is a common ingredient in chewable gels, providing sweetness and enhancing flavors. However, due to health concerns related to excessive sugar consumption, sugar substitutes are often used. Examples include polyols (such as sorbitol, xylitol, and erythritol) and artificial sweeteners (such as sucralose and aspartame). These alternatives offer sweetness without the same caloric impact as sugar [11].

Citric Acid: Citric acid is a natural acid found in citrus fruits and is commonly used in gummies for its tart flavour profile. In addition to enhancing taste, citric acid serves as an acidity regulator, helping to balance the pH of the gummy mixture. This ingredient not only contributes to the overall flavour profile of the gummy but also aids in the preservation of the product [12].

Incorporation of Nutraceutical Compounds

Nutraceutical compounds, such as vitamins, minerals, and herbal extracts, are added to products or diets to improve health or prevent disease. These naturally occurring substances have medicinal qualities and can target specific health benefits, requiring thorough review for evaluation. Overages are intentional extra amounts of active ingredients added to gummies during manufacturing to account for potential losses over time due to factors such as storage conditions and shelf life. These extra amounts ensure that the gummies maintain their labelled potency until the expiration date, even if some degradation occurs[13].

METHODS OF PREPARATION OF CHEWABLE GEL

One prominent technique is the traditional hot-melt gelatin method, extensively utilized for its simplicity. This method involves blending gelatin, water, sweeteners, flavors, and colors, followed by heating and molding into the desired shapes. Additionally, the cold-extrusion method has emerged as a popular choice due to its straightforward process [14]. This method entails cold-extruding a mixture of gelatin, water, and other components into molds without the necessity of heat. Furthermore, the starch molding process has garnered attention, particularly for its appeal to vegetarian and vegan preferences. Instead of gelatin, this method employs a starch-based mixture. Each of these methods presents distinct advantages, ranging from traditional appeal to catering to modern dietary considerations, contributing to the diverse array of chewable gel preparations [15].

In recent years, innovative strategies have emerged to enhance the nutritional profile of gummies. Encapsulation technology is one such method, where active ingredients, such as vitamins or probiotics, are encapsulated within the gummy matrix. This protects these sensitive compounds from degradation, ensuring their potency until consumption. Additionally, the use of sugar-free recipes, utilizing sugar substitutes like polyols, caters to the growing demand for healthier alternatives. These sugar-free gummies are often sweetened with natural fruit juices or stevia, appealing to health-conscious consumers [16].

Furthermore, advances in 3D printing technology have opened up new possibilities for personalized gummy production. Companies can now create custom molds for gummies, allowing for unique shapes and designs tailored to specific consumer preferences. These innovative methods not only improve the nutritional quality of gummies but also offer exciting opportunities for creativity and customization in the production process [17].

EVALUATION OF CHEWABLE GELS

The pharmacopoeias outline several key parameters for evaluating the quality of gummies, ensuring they meet safety and efficacy standards. One essential parameter is the identification test, which confirms the presence of specific ingredients like gelatin or pectin. This test ensures that the gummies contain the intended components. Another critical evaluation is the assay, which quantifies the active ingredients, such as vitamins or minerals, to verify their potency and concentration. This ensures that consumers receive the stated amounts of beneficial nutrients [18]. Additionally, the dissolution test evaluates how quickly the gummies break down in simulated gastric fluid, ensuring optimal absorption in the digestive system. The uniformity of weight test ensures consistency in the weight of individual gummies, guaranteeing accurate dosing for consumers. Furthermore, microbial limits testing assesses the presence of harmful microorganisms, ensuring the safety and shelf-life of the gummies [19].

IMPACT OF CHEWABLE GELS ON HEALTH AND WELLNESS

Nutraceuticals for General Well-being

Nutraceuticals are emerging as a competitive substitute for conventional medicine, enhancing immune system performance, strengthening defences against infections, reducing autoimmune and hypersensitivity issues, and potentially acting as anti-inflammatories, antioxidants, and anti-cancer agents [20]. Nutraceutical science is expanding, leading to new therapeutic approaches. While some nutraceuticals may benefit the immune system, more clinical research is needed to understand their long-term effects and safety. Independent investigation into their nutritional and medical qualities is crucial, as it helps understand their function and potential advantages [21].

Disease Prevention and Management

Heart disease is influenced by various factors such as cholesterol levels, high blood pressure, smoking, diabetes, obesity, poor eating habits, alcohol consumption, mental health disorders, stress, medications, aging, family history, gender, and ethnicity. Lucerne and turmeric can lower cholesterol and plaque buildup, while healthy eating boosts immunity and nutraceuticals play a significant role in prevention and treatment. Natural supplements known as nutraceuticals are frequently employed in veterinary medicine as a multimodal Osteoarthritis treatment [22]. Together glucosamine and chondroitin sulfate help cartilage develop and heal; they additionally reduce the symptoms of OA-related pain. In recent decades, plant chemicals have been widely used as pharmaceutical-grade nutrients, as documented by numerous researchers. In human medicine, Curcuma and Boswellia extracts have long been used to treat wounds, osteoarthritis, and inflammation. The ability of the aromatic vegetable Curcuma longa to affect several important molecular targets, including transcription factors, cytokines, and pro-inflammatory enzymes (COX-LOX), is responsible for its anti-inflammatory effects. However, due to its quick metabolism, systemic clearance, and delayed absorption, Curcuma longa has limited bioavailability [23].

Targeted Nutrition Delivery for Specific Population Groups

Chewable gels have emerged as a promising avenue for delivering targeted nutrition to specific population groups. With their convenient form and pleasant taste, these gels offer a practical solution for individuals who may struggle with traditional supplement forms. For children and older adults, who might find swallowing pills difficult, chewable gels provide an easier and more enjoyable way to get essential nutrients. Athletes and active individuals also benefit, as these gels can be formulated with specific nutrients tailored to support their unique needs, such as electrolytes for hydration or proteins for muscle recovery. Overall, chewable gels represent a user-friendly and effective approach to delivering precise nutrition for various segments of the population, making it easier for them to meet their dietary requirements [24].

Considering Safety: Advantages and Considerations of Chewable Gels

Chewable gels offer numerous advantages and considerations in terms of safety. Firstly, their ease of administration is a key benefit, especially for individuals who struggle with swallowing tablets. This feature reduces the risk of choking and enhances medication adherence, particularly in older adults and children. Additionally, chewable gels often dissolve faster in the stomach compared to regular pills, which can lower the likelihood of gastrointestinal discomfort. This is especially beneficial for medications known to cause stomach irritation. Another advantage is precise dosing, as chewable gels can be formulated with exact amounts of active substances to ensure correct dosage, minimizing the risk of under- or overdosing, which is critical for drugs with narrow therapeutic windows. Moreover, these gels can be flavoured to improve palatability, especially for younger patients, though it's essential to ensure these flavors are safe and won't affect the medication negatively. Storage requirements should also be followed to maintain stability and effectiveness. Like any medication, chewable gels may interact with other drugs, so patients should discuss this with their healthcare provider to avoid potential interactions. Patients should also be advised to chew the gel thoroughly for proper absorption Introduction [25].

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Consumer Acceptability and Compliance

Consumer acceptability and compliance with chewable gels can be influenced by several factors, including taste, convenience, and ease of use. One of the key advantages of chewable gels is their palatability, as they can be formulated in various flavors to enhance taste and make them more appealing to consumers, especially children and older adults. This aspect can significantly improve acceptability, as individuals are more likely to adhere to a regimen if they find the product enjoyable to consume. Furthermore, the convenience of chewable gels, particularly for individuals who have difficulty swallowing pills or capsules, can enhance compliance. The ease of administration eliminates the need for water and allows for on-the-go consumption, making it a convenient option for busy lifestyles. This convenience factor can contribute to higher compliance rates, as consumers are more likely to incorporate the chewable gels into their daily routine. Additionally, clear and user-friendly packaging, along with proper labelling and instructions, can improve consumer acceptability and understanding of how to use the product correctly. Providing information on the benefits of the chewable gels and how they contribute to health and wellness can also motivate consumers to maintain compliance with the recommended dosage. However, despite these advantages, challenges to consumer acceptability and compliance may arise. Some individuals may still prefer traditional dosage forms or may have concerns about the effectiveness of chewable gels compared to other options. Addressing these concerns through education and communication about the benefits of chewable gels can help improve acceptance and compliance rates [28].

CHALLENGES AND FUTURE PERSPECTIVES

In summary, the development of gummies as nutritional supplements involves careful consideration of formulation strategies, excipients, and evaluation methods outlined in pharmacopoeias. Excipients like gelatin, pectin, and starches play vital roles in providing texture and stability, while sugar or sugar substitutes and citric acid enhance flavor and serve as acidity regulators. Innovative methods such as encapsulation technology and 3D printing offer opportunities to improve the nutritional profile and customization of gummies. Pharmacopoeial parameters such as identification tests, assays, dissolution tests, weight uniformity, and microbial limits ensure quality, safety, and efficacy. Overages are added to gummies to compensate for potential losses over time, maintaining labeled potency until the expiration date. Future work in gummies could focus on enhancing their bioavailability further through the development of advanced delivery systems. This includes exploring nanoemulsions and other encapsulation techniques to improve nutrient absorption. Additionally, research on alternative and sustainable excipients to replace traditional ones like gelatin could be beneficial. Further investigation into personalized gummy production using 3D printing technology for tailored nutrient delivery could also be an exciting area for exploration [29].

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