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Nutritional Fortification of Peanut Chikki with Pumpkin Seeds and Vitamin C (Ascorbic Acid): A Review of Functional and Health-Promoting Properties

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Abstract : The current review is based on the concept of nutritionally enriched traditional snack, peanut chikki, by adding pumpkin seeds and fortifying with vitamin C (ascorbic acid). Peanut chikki is a popular jaggery-based confectionery that is highly appreciated due to its energy value and mineral supply but does not contain all the micronutrients and functional ingredients needed by the modern diet. The protein, essential fatty acids, minerals and antioxidants in pumpkin seeds make it a good choice in enriching nutritional value. Moreover, vitamin C is vital in improving antioxidant effects and mineral bioavailability, especially absorption of iron. This paper is based on the use of secondary data in the form of scientific literature in order to measure nutritional composition, functional properties, processing methods, sensory properties, and stability of fortified chikki in terms of storage. Problems regarding vitamin C stability and shelf life of the products are also reviewed. Formulation strategies are comprehended by comparison of similar fortified food systems. The results show that the incorporation of traditional snack matrices and functional ingredients can be an effective way to enhance the health benefits without compromising consumer acceptability. The paper identifies the potential of peanut-pumpkin seed chikki as a functional, low-cost and health-promoting snack in accordance with the existing clean-label and nutraceutical food trends.

Keywords: Peanut Chikki, Pumpkin Seeds, Vitamin C, Ascorbic Acid, Fortification

IndexTerms **- Component, formatting, style, styling, insert.**

INTRODUCTION

The use of traditional food systems is increasingly being experimented with as a viable means of providing improved nutrition by incorporating functional ingredients into them. Traditional snacks are also common in most countries such as India because they are cheap, readily available and acceptable in most cultures. An example of a high-energy content, plant-based protein, and mineral-rich (iron and magnesium) peanut chikki, a traditional confection consisting of roasted peanuts and jaggery, is popular due to its high energy content (Abhirami & Karpagapandi, 2018).

Nevertheless, being nutritionally balanced, peanut chikki does not contain some micronutrients and functional ingredients essential to fulfill modern dietary requirements. Due to the growing consciousness on health and growing cases of micronutrient deficiencies, there has been an increased interest in foods that have nutritional value and other health provisions (Attia, 2020). This has seen the emergence of functional foods where the traditional products are fortified with nutrient enriching ingredients. The presence of high protein content, unsaturated fatty acids, dietary fiber and essential minerals like zinc and magnesium have made pumpkin seeds an important functional ingredient. Bioactive compounds have also antioxidant effects and are found in them, leading to better health outcomes. It has been demonstrated that their addition to food products improves both the nutritional value and texture and sensory properties (Bashir et al., 2025).

Also, vitamin C (ascorbic acid) fortification is a valuable strategy that can contribute to the antioxidant capacity and iron absorption in plant foods (Oluyimika et al., 2019). Nevertheless, when processing and storage, vitamin C is vulnerable to heat, light, and oxygen, which degrade it, making it a challenge to formulate products (Yin et al., 2022).

Thus, the introduction of peanut chikki with pumpkin seeds and vitamin C provides a good solution to come up with a functional snack with a better nutritional and health value. The method integrates the conventional food culture with the contemporary nutritional approaches to address the changing consumer needs (Kabir et al., 2026).

Problem Statement

Despite the nutritional value of peanut chikki, it does not have enough micronutrients and functional ingredients to comply with the current dietary guidelines. Current prescriptions lack nutrient-rich seeds and nutrient deficiencies are not addressed by fortification. Also, preserving product texture, nutrient stability, especially vitamin C and consumer acceptability are some of the challenges that hamper product development. As such, there is need to come up with a fortified peanut chikki that has better nutritional value, functional and storage stability.

Nutritional Importance of Peanuts and Pumpkin Seeds in Chikki Development

Nutritionally dense foods such as peanuts and pumpkin seeds add a lot of value to the traditional chikki since they increase the macronutrient and micronutrient content of the chikki (Znamirowska et al., 2021). They are used together in order to achieve a balanced and functional snack item.

Protein and Energy Source – Peanuts are a great source of plant-based protein and a great source of energy because of its fat content. The level of protein and provision of essential amino acids also increase due to pumpkin seeds and help to enhance the nutritional value in general (Bonku & Yu, 2020).

Healthy Lipid Profile – Peanuts and pumpkin seeds are rich in unsaturated fatty acids, such as oleic and linoleic acids, that are good heart-protective and aid in keeping cholesterol levels in check (Gavril et al., 2024).

Mineral Richness – Pumpkin seeds are especially full of crucial minerals like zinc, magnesium, iron, and phosphorus, which are crucial in metabolism, immunity, and bone strength. Mineral intake is also provided by peanuts, in particular, magnesium and potassium (Amin et al., 2022; Rao et al., 2021).

Dietary Fiber Content – Pumpkin seeds are a good source of dietary fiber, which benefits the digestive system, enhances satiety, and maintains blood sugar levels. This provides functionality to the chikki formulation (Gavril et al., 2024).

Bioactive Compounds – Both products include bioactive compounds like antioxidants, phytosterols and phenolic compounds. These substances have anti-inflammatory, antioxidant, and preventive disease effects, which lead to a comprehensive improvement in health (Bonku & Yu, 2020).

Functional Food Potential – Research on the nutri-chikki and other products of this type has shown that the addition of other ingredients with higher nutritional density, functional characteristics, and storage stability is a significant boost to nutritional density, functionalities, and storage stability. This is in line with the possibility of coming up with value added chikki products with better health effects (Abhirami & Karpagapandi, 2018).

Synergistic Nutritional Effect – The combination of peanuts and pumpkin seeds provides a complementary nutrient profile, where proteins, healthy fats, minerals, and bioactive compounds work together to enhance the overall functional quality of the product.

Table 1: Nutritional Contribution of Major Ingredients in Fortified Chikki

Component	Peanuts	Pumpkin Seeds	Jaggery	Functional Benefit
Protein	High (25.8 g/100g)	Very High (18.6-39.3 g/100g)	Low (0.4 g/100g)	Muscle growth, satiety
Fats	Healthy fats (49.2 g/100g)	Unsaturated fats (19.4-49.1 g/100g)	Negligible (0.1 g/100g)	Energy, heart health
Minerals	Iron, Mg, P, K	Zn, Mg, Fe, P, K	Iron, Ca, Mg, K	Immunity, metabolism
Fiber	Moderate (8.5 g/100g)	High (5.2-18.4 g/100g)	Low (0.5 g/100g)	Digestive health
Antioxidants	Moderate (phenolics, resveratrol)	High (phenolics, tocopherols, carotenoids)	Low (phenolics)	Oxidative stress reduction
References	*USDA (2024); Bonku & Yu (2020)*	*Amin et al. (2022); Gavril et al. (2024)*	*Rao et al. (2021); Shrivastava & Singh (2020)*	—

Source: Compiled from USDA National Nutrient Database (2024); Amin et al. (2022); Bonku & Yu (2020); Gavril et al. (2024); Rao et al. (2021); Shrivastava & Singh (2020).

Role of Pumpkin Seeds in Functional and Sensory Enhancement

Pumpkin seeds are an important functional ingredient in improving the nutritional and sensory qualities of food products, including functional snacks like peanut chikki. Adding pumpkin seeds enhances the nutritional value of the product by boosting protein, fiber, essential fatty acids and antioxidants (Gavril et al., 2024). These changes in nutritional value lead to improved health benefits, such as improved digestion, stronger immunity and reduced oxidative stress.

In terms of functionality, pumpkin seeds have a positive impact on the product's structure and physicochemical characteristics. The presence of oil in the seeds improves binding and adhesion in the matrix, which increases the stickiness and decreases the crunchiness of the chikki. The dietary fiber content also affects the texture and chewiness of the product which can be controlled by suitable levels of pumpkin seeds in the formulation. They also enhance water holding capacity and stability of the matrix (Mujaffar & Ramsumair, 2019).

In terms of taste and texture, pumpkin seeds have a subtle nutty taste which augments the sweetness of jaggery and roastiness of peanuts. This combination results in improved taste and acceptability. The natural oils in pumpkin seeds add a creamy texture, while the seeds themselves add a crunchy texture. Research on pumpkin seed supplementation in bakery and cereal products has shown enhanced texture, taste and sensory acceptability, suggesting their potential for value-added food products (Lerdluksamee et al., 2025).

Additionally, pumpkin seeds have inherent antioxidants like phenolic compounds and tocopherols, that provide stability against oxidation. These substances inhibit lipid oxidation, thus improving product stability and thus maintaining its sensory quality during storage (Mujaffar & Ramsumair, 2019). In summary, pumpkin seed addition improves the performance and acceptability of peanut chikki.

Role of Vitamin C (Ascorbic Acid) in Food Fortification and Stability

Vitamin C (ascorbic acid) is a vital water-soluble vitamin with potent antioxidant functions and crucial health benefits. It is essential for boosting the immune system, decreasing oxidative damage and increasing the bioavailablility of non-heme iron from plant sources (Rani et al., 2024). Adding vitamin C to foods like peanut chikki enhances their functional properties by boosting their nutritional value and health-promoting properties.

Enhancement of Mineral Bioavailability – Vitamin C plays a critical role in improving iron absorption by converting iron into its more absorbable form. This is especially important in plant-derived foods, which have low iron bioavailability (Oluyimika et al., 2019).

Antioxidant Function – Vitamin C is a strong antioxidant, which scavenges free radicals and prevents the oxidation of food ingredients, particularly fats. This helps to reduce rancidity and enhance product stability and shelf life (Paciolla et al., 2019).

Role in Nutritional Fortification – Vitamin C addition enhances the micronutrient profile of the product, enabling it for use in fortification to combat nutritional deficiencies, such as in at-risk populations. It also contributes to the functional characteristics of the product as a nutritious snack (Comunian et al., 2022).

Stability Challenges – Vitamin C, despite its advantages, has poor stability in a set of environmental conditions (temperature, light, oxygen, pH). This can result in substantial losses during processing and storage, diminishing its efficacy in fortified products (Yin et al., 2022).

Encapsulation and Protection Techniques – To address stability challenges, cutting-edge technologies like microencapsulation and nanoencapsulation are employed to shield vitamin C. These techniques aid in the controlled delivery, stability, and retention of nutrients in food products (Comunian et al., 2022).

Application in Food Systems – In foods such as chikki, it is ideal to add vitamin C after the heating process, such as coating or dusting, in order to retain the functional properties and avoid the degradation of vitamin C (Yin et al., 2022).
In conclusion, vitamin C fortification improves the nutrient value, antioxidant ability and functional properties of peanut chikki but strategic processing and formulation approaches need to be followed for its stability.

Table 2: Factors Affecting Stability of Vitamin C in Food Products

Factor	Effect on Vitamin C	Impact on Product	References
Heat	Thermal degradation (first-order kinetics); loss of 10-90% depending on temperature and duration	Reduced nutritional value; loss of bioactivity	*Yin et al. (2022); Comunian et al. (2022)*
Oxygen	Oxidative degradation; conversion to dehydroascorbic acid	Loss of antioxidant activity; off-flavor development	*Paciolla et al. (2019); Jakubek et al. (2023)*
Light	Photodegradation; rapid degradation under UV and visible light	Nutrient loss; color changes in product	*Yin et al. (2022); Comunian et al. (2022)*
Storage Time	Gradual decline; 50% loss within 1-3 months at ambient conditions	Reduced shelf-life quality; decreased functional value	*Znamirowska et al. (2021); Yin et al. (2022)*
Processing Method	Variable retention: coating/dusting > encapsulation > direct addition > heating	Affects fortification efficiency; determines final vitamin C content	*Comunian et al. (2022); Yin et al. (2022)*

Source: Adapted from Yin et al. (2022); Comunian et al. (2022); Paciolla et al. (2019); Jakubek et al. (2023); Znamirowska et al. (2021).

Processing and Preparation of Peanut Chikki

The production of peanut chikki is a multi-step process that controls its characteristic texture, quality, nutritional value and consumer acceptability (Nair & Augustine, 2018). Careful monitoring of these processes is critical, particularly when other ingredients like pumpkin seeds and vitamin C are added.
Selection and Preparation of Raw Materials – Superior grade peanuts and pumpkin seeds are chosen, cleaned, and roasted for improved flavour, moisture reduction, and digestibility. Roasting also creates flavour and brown colour via the Maillard reaction.
Jaggery Heating and Syrup Formation – Jaggery is heated to a particular temperature to create a syrup, which serves as a binder. Heating to a suitable temperature and for an appropriate duration is critical to achieve the desired texture of chikki – if not heated properly, the chikki may remain soft, and if overheated, may become bitter (Rao et al., 2021).
Ingredient Mixing – Roasted peanuts and pumpkin seeds are thoroughly mixed with the hot jaggery syrup to ensure the ingredients are well coated. Ensuring uniform mixing is critical for achieving uniform texture, structure and flavour.
Sheeting and Shaping – The blend is rapidly spread out to form thin sheets and shaped into various shapes. This process should be done quickly to ensure consistent thickness and texture.
Cooling and Solidification – Fast cooling is required to maintain crunchiness and avoid water absorption. Appropriate cooling conditions help to achieve desired crispiness and shelf life.
Fortification Step – Vitamin C is heat sensitive and therefore, preferably added after the cooking process, such as by coating or dusting. This helps prevent heat-induced damage and preserves its nutritional and antioxidant values (Yin et al., 2022).
Packaging Considerations – Adequate packaging in moisture and oxygen-impermeable packaging materials helps maintain texture, prevent oxidation and improve shelf life.
In summary, fine-tuning processing variables is critical to achieve a quality fortified chikki product with optimal nutritional and sensory properties.

Effect of Ingredient Enrichment on Texture and Acceptability

The addition of functional ingredients like pumpkin seeds and vitamin C play a crucial role in determining the physical, textural and sensory attributes of peanut chikki. These enrichments not only improve the nutrition profile, but also affect the physical properties and hence need to be balanced.
The addition of more pumpkin seeds leads to an increase in protein, fiber and fat content, which may influence the hardness, chewiness and brittleness of chikki (Devhare et al., 2020). Increased amounts of fats from seeds may contribute to better mouthfeel and prevent excessive hardness, but excess fats may also affect binding properties, causing different structural changes. So, ingredient ratios must be carefully adjusted to achieve the desired brittle and crunchy texture of chikki.

In terms of texture, a moderate amount of seeds enhances the crunch and gives a satisfying mouthfeel; however, higher levels may lead to a heavy or excessively hard product. The jaggery matrix helps to achieve a balance by offering enough binding and firmness (Mohamed et al., 2025).

Sensory properties (flavor, texture, appearance, mouthfeel) play a major role in consumer acceptance of a product. Pumpkin seeds contribute a nutty flavor, which balances the sweetness of jaggery and peanuts. This enhances taste acceptance and overall acceptability.

Research on other fortified foods suggest that the inclusion of moderate amounts of ingredients leads to higher sensory scores, whereas high fortification levels can adversely affect taste and texture (Singh et al., 2017). Furthermore, the appearance of the product, such as colour and consistency, also contributes to consumer preference.

In summary, the key to the successful formulation of fortified peanut chikki is striking the right balance between nutritional fortification and sensory attributes. Good formulation guarantees that peanut chikki will be healthy and palatable.

Shelf-Life Stability and Quality Evaluation

Peanut chikki is generally stable in terms of shelf-life because of its low water content and water activity, and this restricts the growth of microorganisms. The high sugar content from jaggery also helps to preserve the product, enhancing its shelf life. But the fat content (from peanuts and pumpkin seeds) can lead to rancidity with time. Lipid oxidation can result in the formation of off-flavours and off-odours and a loss of nutritional value.

The use of antioxidants like vitamin C helps to slow down oxidation. Vitamin C scavenges free radicals, thus preventing lipid and other labile components from oxidation, and enhancing the shelf life of the product (Paciolla et al., 2019). Moreover, intrinsic antioxidants found in pumpkin seeds, such as phenolic compounds, also play a role in maintaining oxidative stability and product quality.

The shelf life of fortified chikki depends on various factors such as storage temperature, light and air exposure, and packaging. Higher temperatures and exposure to oxygen increase the risk of oxidation and loss of nutrients, especially heat- and oxygen-sensitive components such as vitamin C. So, proper storage conditions are critical to ensure nutrient retention and product quality (Jaiswal et al., 2020).

Appropriate packaging is vital for shelf life. Barrier packaging that is air-, moisture-, and oxygen-resistant (such as vacuum or laminated films) is essential to limit moisture uptake, oxidation and microbial spoilage. Packaging also shields the product from other environmental conditions like light and humidity, which helps preserve the product's texture, taste, and quality.

Quality assessment parameters such as moisture, peroxide value, sensory evaluation and texture measurement are required to determine product stability (Gurwara et al., 2023). With proper storage conditions, peanut chikki can be stored for a few weeks to months, depending on product formula and packaging performance.

Consumer Trends and Market Potential

There has been a surge in the market for functional and healthful snack foods in recent years because of increasing awareness of health and nutrition. Consumers now demand products that can not only give them energy but also have secondary health-promoting benefits, such as digestive health, immunity, and nutrient absorption (Comunian et al., 2022). As a result, there has been an increase in the consumption of functional foods and nutraceuticals.

There is a growing market demand for plant-based and clean-label foods, which are preferred for their natural ingredients, minimal processing and lack of synthetic additives. The fortification of traditional foods with nutrients is especially appealing as it adds value without compromising taste (Salis et al., 2021).

In this regard, fortified peanut chikki is an exciting product with good market prospects. This product taps into trends by providing an inexpensive, convenient, plant-based, protein rich and mineral fortified snack. The addition of pumpkin seeds enhances its nutritional profile, and the vitamin C fortification provides a further health benefit linked to antioxidant properties and mineral absorption.

Moreover, the snack can be targeted towards different market segments, such as children, teens, and health-conscious consumers. It could also be used as an additional snack in nutrition programs to rectify micronutrient malnutrition. Its convenience, stability and portability add to its potential (Jakubek et al., 2023).

In conclusion, the preparation of peanut chikki fortified with pumpkin seeds and vitamin C is in line with the current consumer trends and demands, thus making it a potential functional and sustainable product.

Conclusion

This review stresses that peanut chikki fortified with pumpkin seeds and vitamin C is an excellent functional snack with enhanced nutritional and health properties. Pumpkin seeds help increase the product's protein, mineral (zinc and magnesium) and antioxidant content, and hence improves the overall nutritional value. Similarly, addition of vitamin C is extremely important in enhancing iron availability, antioxidant potential and boosting immunity.

Despite these advantages, certain challenges remain, particularly regarding the stability of vitamin C during processing and storage, as well as the potential impact of ingredient enrichment on texture and sensory characteristics. However, these

limitations can be effectively managed through optimized formulation, controlled processing conditions, and appropriate fortification techniques such as post-processing addition or protective delivery systems.

Furthermore, the development of such value-added chikki aligns well with current consumer trends that favor functional, plant-based, and clean-label foods. It also offers a practical approach for enhancing the nutritional profile of traditional snacks without compromising their cultural acceptability and affordability.

Overall, the integration of nutrient-dense ingredients and micronutrient fortification into traditional food products like peanut chikki provides a viable strategy for developing health-promoting, convenient, and consumer-friendly snack options with significant potential for both nutritional improvement and commercial application.

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