DEVELOPMENT AND QUALITY EVALUATION OF CAKE INCORPORATED WITH AMARANTH (Amaranthus viridis) LEAF POWDER

BY

NERIN K S (2020-06-017)

DILNA K DILEEP (2020-06-018)

SANYA SUNNY (2020-06-021)

MALAVIKA E (2020-06-027)

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF PROCESSING AND FOOD TECHNOLOGY

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY, TAVANUR, MALAPPURAM-679573

KERALA, INDIA

2023-2024

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PROJECT REPORT

Submitted in fulfilment of the requirement for the degree of

BACHELOR OF TECHNOLOGY IN FOOD TECHNOLOGY

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF PROCESSING AND FOOD TECHNOLOGY

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY, TAVANUR, MALAPPURAM-679573

KERALA, INDIA

2024

DECLARATION

I hereby declare that this thesis entitled "DEVELOPMENT AND QUALITY EVALUATION OF CAKE INCORPORATED WITH AMARANTH (*Amaranthus viridis*) LEAF POWDER" is a bonafide record or research work done by us during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title of any other University or Society.

Place: Tavanur

Date: 24/01/2024

NERIN K S (2020-06-017)

DILNA K DILEEP (2020-06-018)

SANYA SUNNY (2020-06-021)

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CERTIFICATE

Certified that this thesis entitled "DEVELOPMENT AND QUALITY EVALUATION OF CAKE INCORPORATED WITH AMARANTH (*Amaranthus viridis*) LEAF POWDER" is a bonafide record of research work done independently by NERIN K S (2020-06-017), DILNA K DILEEP (2020-06-018), SANYA SUNNY (2020-06-021) and MALAVIKA E (2020-06-027) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associate ship.

Place: Tavanur

Date: 24/01/2024

Dr. Prince M.V

(Major Advisor, Advisory committee)

Professor & Head

Dept. of Processing and Food Engineering

ACKNOWLEDGEMENT

Any accomplishment requires the efforts of many people, and this work is no different. We found great pleasure in expressing our deep sense of gratitude towards all those who have made it possible for us to complete this project with success. First of all, we would like to express our true and sincere gratitude to our mentor Mrs. Sreeja R, Assistant Professor, Dept. of Processing and Food Engineering, Kelappaji College of Agricultural Engineering and Technology, Tavanur, for her dynamic and valuable guidance, care, patience and keen interest in our project work. This project has been a result of the combined efforts of our guide and us. She has been a strong and reassuring support to us throughout this project. We consider it our greatest fortune to have her as the guide of our project work and our obligation to her lasts forever. With great gratitude and due respect, we express our heartfelt thanks to Dr. Jayan PR, Dean, KCAET, Tavanur for his support while carrying out the project work. We engrave our deep sense of gratitude to Dr. Prince M V, HOD, Dept. of Processing and Food Engineering, Dr. Rajesh G K, Assistant Professor, Dept. of Processing and Food Engineering, Mrs. Sreeja R, Assistant Professor and Dr. Senthilkumar R, Assistant Professor. We express our gratitude to Mrs Geetha, Lab Assistant for their immense help. We express our thanks to all library staff members, KCAET, Tavanur, for their ever willing help and cooperation. We express our sincere thanks and gratitude to Kerala Agricultural University for providing this opportunity to do the project work. We are greatly indebted to our parents for their love, blessings and support which gave strength to complete our study. We also acknowledge our friend for their support and care throughout the project duration. Last but not the least; we bow our heads before God Almighty for the blessings bestowed upon us which made us materialize this endeavour.

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CHAPTER I

INTRODUCTION

Snacking is a vital pattern of consumption that supports meeting the daily nutritional needs of children, which substantially contributes to healthy growth and development (Serrano and Powell, 2013). Processed snacks are primary nutrient sources, viz. energy, protein, iron, calcium, and vitamins. In low and medium income countries in Asia, Latin America, and Africa, processed snacks are becoming increasingly popular (Huffman *et al*., 2014). The consumption of snacks in South Africa was reported to increase by 53.3% from 1992 to 2012, especially among children (Ronquest *et al*., 2015). Among the snacks, cakes are one of the most popular bakery items consumed by nearly all classes of people due to their ready-to-eat nature and availability in various types at an affordable price (Ben *et al*., 2017). Currently, baked cakes are an essential part of pre-schooler's diet to meet their nutritional demand alongside staple food. Traditional cakes are usually prepared from wheat flour, added sugar, eggs, and baking powder (Atef *et al*., 2011). However, this type of cake is high in sugar and rich in carbohydrates and fat but low in other nutrients, including protein, minerals, and vitamins (Ameh *et al*., 2013). Furthermore, the World Health Organization (WHO) reported snacks with high sugar and fat content as unhealthy (WHO, 2013). In this context, the demand for functional food with higher nutrients and minerals has risen. Micronutrient deficiencies are most prevalent in Sub-Saharan Africa and Southern Asia, especially in women and young children (Black *et al*., 2013). Several studies reported that about 16 million children are malnourished world-wide, with 2.3 million children in South Africa having stunted growth and nutritional deficiencies. The use of locally available, inexpensive, and nutrient-rich plant materials in cake formulations must be recognized and promoted to enhance health and nutritional safety in that particular region.

Green amaranth (*Amaranthus viridis*) is an Indian sub-continent native plant that naturalized itself worldwide in tropical and subtropical regions (Moyo *et al*., 2011). The green amaranth leaf, a vibrant and verdant emblem of nutritional excellence, belongs to the botanical marvel Amaranthus viridis, a species that has graced the tables of civilizations across centuries. Characterized by its lush, dark green hue and uniquely crinkled texture, this leafy vegetable is a powerhouse of health benefits. A nutritional titan, green amaranth is renowned for its impressive array of vitamins and minerals These leaves are excellent as a source of vitamins A, B, and C and are known as one of the best plant mineral and iron sources (Sengev *et al*., 2013). Rich in vitamin A, essential for maintaining healthy vision, vitamin C, a potent antioxidant that boosts the immune system, and vitamin K, crucial for blood clotting and bone health, green amaranth stands as a beacon of micronutrient abundance. Green amaranth leaf was also reported to contain a high amount of protein (28.25%), iron, calcium, phosphorous, magnesium, manganese, and zinc (Nahriana and Tawani, 2019). Moreover, Green amaranth leaf was reported to have a high content of essential amino acids, alpha- linoleic acid and a wide range of dietary antioxidants (Oyeyinka and Oyeyinka, 2018). Green amaranth leaf is rich in phenolic compounds (e.g., phenolic acids, flavonoids, etc.). The anti-oxidative functionality of these compounds makes Green amaranth a promising natural additive that can be applied to foods for enhancing human nutrition (Devisetti *et al*., 2016). Many studies have reported the potential use of Green amaranth leaves in making diverse food such as soups, weaning food, herbal biscuits, bread, and yogurt (Oyeyinka and Oyeyinka, 2018). Thus, the idea was born of fortifying the Green amaranth leaf with other ingredients, such as refined wheat flour; to prepare a food with a better nutritional composition can increase its consumption among different populations with improved nutritional safety. Green amaranth leaves fortified in a food item, have enormous potentials to meet the nutritional demand in developing and underdeveloped countries, where high value animal protein and fruits are beyond the reach of impoverished people. the green amaranth leaf is not merely an ingredient; it is a culinary muse and a symbol of gastronomic innovation. Its adaptability and nutrient density have propelled it into the culinary spotlight, where it not only tantalizes taste buds but also nourishes bodies. Whether elegantly adorned in a salad, blended into a nutritious smoothie, or expertly woven into a sumptuous main course, the green amaranth leaf emerges as an ambassador of both flavor and well-being. As societies continue to embrace the pursuit of wholesome living, the green amaranth leaf remains an enduring ally in the journey towards a healthier and more vibrant lifestyle. However, a fortificant inclusion of Green amaranth in various food items in a proportion that the taste remains intact and the nutritional value increases exponentially is still a challenging issue. Therefore, the current research entitled "**Development and Quality Evaluation of cake incorporated with amaranth (*Amaranthus viridis*) leaf powder**" was with following objectives,

1. To evaluate the nutritional composition of dried green amaranth leaf powder
2. Preparation and Standardisation of green amaranth leaf powder fortified cake
3. To determine the nutritional composition of the cake fortified with Green amaranth leaf powder
4. To evaluate the sensory quality of green amaranth leaf powder fortified cake to justify consumer acceptability

CHAPTER II

REVIEW OF LITERATURE

The literature reviewed for the present study entitled ‘‘Development and quality evaluation of cake fortified with amaranth (*Amaranthus viridis*)’’ is presented under the following sub-heads.

2.1 Nutritive value of green amaranth

The green amaranth leaf, scientifically known as *Amaranthus viridis*, is a versatile and nutrient-packed green leafy vegetable that has been cultivated for centuries. Its distinctive dark green color and crinkled texture make it easily recognizable in the world of vegetables. Green amaranth is renowned for its exceptional nutritional profile, being rich in vitamins such as A, C, and K, as well as minerals like iron and calcium. Additionally, it provides a good dose of fibre, antioxidants, and folate, making it a valuable component of a healthy diet. The mild and slightly sweet flavor of green amaranth makes it a versatile ingredient in various culinary applications, from salads and smoothies to cooked dishes like sautés, soups, and casseroles. Its adaptability and health benefits have solidified the green amaranth leaf's status as a staple in many cuisines worldwide, contributing not only to culinary delight but also to overall well- being.

Green amaranth holds profound nutritional significance due to its rich and diverse array of essential vitamins, minerals, and antioxidants. A potent source of vitamin K, it plays a pivotal role in blood clotting and bone health. The abundance of beta-carotene in green amaranth contributes to vitamin A levels, supporting vision, immune function, and skin health. Additionally, its vitamin C content acts as a powerful antioxidant, fostering a robust immune system and aiding in collagen formation. Green amaranth stands out for its folate content, vital for DNA synthesis and cell division, making it especially beneficial during pregnancy. Despite its non-heme iron form, green amaranth contributes to overall iron intake, preventing anaemia. The inclusion of calcium further supports bone health, albeit in smaller concentrations than dairy products. Rich in antioxidants like lutein and zeaxanthin, green amaranth combats oxidative stress, potentially lowering the risk of chronic diseases. Its dietary fibre content promotes digestive health and weight management. With a low caloric profile, green amaranth is a nutrient-dense choice for those seeking a health-conscious diet. In summary, the nutritional significance of green amaranth encompasses a spectrum of vitamins, minerals, and antioxidants, making it a valuable addition to a well-rounded and wholesome diet.

Every part of *amaranthus viridis* is a storehouse of important nutrients and antinutrients. The leaves of Amaranthus viridis are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper. Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E also present in Amaranthus viridis (Mibikay, 2012). Green amaranth leaves also have a low calorific value and can be used in the diet of the obese.

Green amaranth leaves boast an impressive nutritive profile, making them a valuable addition to a well-rounded diet. Packed with essential vitamins, green amaranth is a rich source of vitamin A, promoting vision health, vitamin C, a potent antioxidant supporting the immune system, and vitamin K, crucial for blood clotting and bone health. The mineral content is notable, with iron aiding in red blood cell formation, calcium contributing to bone strength, and potassium regulating blood pressure. Additionally, green amaranth provides folate, vital for DNA synthesis, and dietary fibre for digestive health. Abundant in antioxidants such as beta-carotene, lutein, and zeaxanthin, green amaranth helps combat oxidative stress. With its low-calorie content and versatile culinary applications, green amaranth stands as a nutrient-dense leafy green, offering a delectable and healthful boost to overall well-being.

2.2 Nutritive value of dried green amaranth

Dried green amaranth, an innovative and convenient derivative of the leafy green, retains a remarkable array of nutritive value, providing a nutrient-dense alternative to its fresh counterpart. While the dehydration process removes water content, the essential vitamins and minerals within green amaranth persist in concentrated form, making it a valuable addition to a balanced diet. One of the key nutritional components of dried green amaranth is its retention of vitamin A, essential for maintaining healthy vision and supporting immune function. Vitamin C, a powerful antioxidant crucial for immune health, persists in dried green amaranth, contributing to overall well-being. The concentration of vitamin K in dried green amaranth remains significant, supporting bone health and aiding in blood clotting. Minerals, such as iron and calcium, though marginally reduced through dehydration, continue to be noteworthy contributors to their respective roles in red blood cell formation and bone strength. The retention of potassium, vital for regulating blood pressure, makes dried green amaranth a valuable source of this essential mineral. Folate, a B-vitamin important for cell growth and DNA synthesis, remains present in dried green amaranth, providing benefits for reproductive and developmental health. The enduring fibre content in dried green amaranth supports digestive health and offers a sense of satiety, despite the removal of water. Antioxidants like beta-carotene, lutein, and zeaxanthin, integral for neutralizing free radicals and supporting cellular health, are also concentrated in dried green amaranth. This makes it a convenient source of these protective compounds, even in its dehydrated state.

World Health Organization (WHO) estimated 190 million pre-school children to be the victims of deficiency of one or more micro-nutrients including vitamin A and iron (Paul *et al*., 2017). Available information suggests increased production of food crops as a means to bridge up inherent nutritional inadequacies and losses. In addition to food fortification, dietary diversification serves as a sustainable approach to subside micronutrient malnutrition and related health challenges (Lindsay *et al*., 2006). Staple food crops and the products made thereof are recommended as potential means to mitigate micronutrient deficiencies in developing world (Khan *et al*., 2015). Together with an array of bioactive compounds, green amaranth is regarded as a source of essential nutrients that may help in preventing a variety of nutritional disorders. Cereals based bakery products are the most common, viable, and acceptable consumable goods in various cultures. Sufficient literature demonstrates the application of vegetables as natural additives to improve nutritional and functional properties of baked goods, for example, carrot pomace-based bread and cakes (Kumar and Kumar, 2012), flaxseed powder-based muffins (Sudha *et al*., 2010), fenugreek flour-based biscuits (Hooda and Jood, 2005), and lotus seed flour-based cookies (Shahzad *et al*., 2020).

Table 2.1. Nutritional composition of fresh and dried green amaranth leaf powder

Nutrients	Leaf powder	Fresh leaves
Moisture (%)	6.35	68.84
Total solids (%)	93.65	31.16
Ash (%)	17.97	2.39
Total protein (%)	31.15	9.29
Fat (%)	3.87	13
Carbohydrate (%)	16.40	6.84
Crude fibre (%)	24.26	-
DPPH (%)	48.58	3.40
TPC (mg/g)	11.63	29.78
Ca (mg/100g)	2988	35475
K (mg/100g)	3334	1373
Mg (mg/100g)	1428	2639
Fe (mg/100g)	26.629	42.76
Zn (mg/100g)	323	23.25
Cu (mg/100g)	0.718	3.86
Mn (mg/100g)	4.80	4.35
L*	47.33	70.05
a*	-3.14	-1.17
b*	15.36	21.49

2.3 Value of green leafy vegetables incorporation in bakery products

Green leafy vegetables, renowned for their rich vitamin and mineral content, bring a host of health benefits when seamlessly integrated into bakery items. This trend not only caters to the demand for more nutritious food options but also adds a delightful and wholesome dimension to traditional baked goods. One of the primary advantages of incorporating green leafy vegetables into bakery products lies in their vitamin content. Vegetables such as green amaranth, kale, and Swiss chard are excellent sources of vitamins A, C, and K. The inclusion of these vitamins enhances the nutritional profile of bakery items, promoting better immune function, vision health, and blood clotting.

Minerals, essential for various physiological functions, are also abundant in green leafy vegetables. Incorporating these vegetables into bakery products introduces elements like iron, calcium, and potassium. Iron is critical for preventing anaemia and ensuring proper oxygen transport, while calcium supports bone health, and potassium regulates blood pressure. By infusing bakery items with these minerals, they become not only flavorful but also contribute to overall health and well-being. Moreover, green leafy vegetables bring substantial fibre content to bakery products. Dietary fibre is crucial for digestive health and helps maintain a feeling of fullness, promoting satiety. This addition addresses the growing consumer interest in foods that support gut health and weight management.

The phytonutrients and antioxidants found in green leafy vegetables further elevate the nutritive value of bakery products. Compounds such as chlorophyll, carotenoids, and flavonoids contribute to cellular health and possess antioxidant properties that combat oxidative stress, potentially reducing the risk of chronic diseases. In the culinary realm, the incorporation of green leafy vegetables into bakery products allows for creative and diverse offerings. From green amaranth-infused muffins to kale-enhanced bread, the possibilities are vast. This not only diversifies the flavor profile of baked goods but also attracts health-conscious consumers seeking nutrient-dense options.

Vegetables are quick sources of energy and are highly beneficial for the normal growth and development of the human body. Vegetables possess essential chlorophyll contents, micronutrients, vitamins, proximates and oxalates. However, vegetables sold in markets are expensive, low quality, stale and contain low micronutrients and minerals while also possessing high contents of tannins, which are toxic for human health.

Furthermore, the vegetables of the market have high concentrations of heavy metals (copper, cadmium, arsenic, mercury, lead and zinc), which are extremely toxic for human health and may even cause death. In developing countries such as Pakistan, heavy metals in market vegetables are due to industrial emission, sewage waste and metal-containing fertilizers.

2.4 Physical and engineering properties of green leafy vegetables incorporated cake

The incorporation of green leafy vegetables into cake recipes represents a fascinating convergence of culinary innovation and nutritional enhancement. This trend, driven by a growing awareness of the health benefits associated with plant-based diets, introduces a myriad of changes in both the physical characteristics and engineering dynamics of traditional cakes.

Plants, including herbs and spices, have many phytochemicals which are a potential source of natural antioxidant, e.g., phenolic diterpenes, flavonoids, alkaloids, tannins and phenolic acids (Amro *et al*., 2002). Natural antioxidants are known to protect cells from damage induced by oxidative stress, which is generally considered to be a cause of aging, degenerative diseases, and cancer (Ringman *et al*., 2005). These health promoting effects of antioxidants from plants and spices are thought to arise from their protective effects by counteracting reactive oxygen species (ROS). Spices, like turmeric, fenugreek, mustard, ginger, etc. may offer many health benefits and have been proven to counteract oxidative stress in vitro and in vivo (Modak *et al*., 2007). Most of these spices have been intensely studied only for their active components like phenolic acids and flavonoids (Manda *et al*., 2010).

One of the most palpable alterations is observed in the texture and moisture content of cakes. Green leafy vegetables, such as green amaranth or kale, bring with them inherent water content and dietary fibre. These components play a pivotal role in shaping the crumb structure and mouthfeel of the cake. A study by Saeed and Pasha

(2017), investigating the effects of green amaranth powder in sponge cake, highlights the nuanced relationship between vegetable incorporation and the resulting texture and moisture attributes.

Achieving an optimal balance becomes crucial, as an excess of moisture may lead to a dense or overly moist cake, while too little can result in a dry and crumbly texture. Furthermore, the color and appearance of cakes undergo a striking transformation with the addition of green leafy vegetables. The vibrant pigments, particularly chlorophyll, inherent in these vegetables introduce a green hue to the cake. This alteration in color not only adds a visually appealing aspect but also serves as a clear indicator of the infusion of healthful plant components. Research by Kowalski and Pawłowski (2018) on the enrichment of cakes with carrot pomace sheds light on how the introduction of plant material can influence the overall aesthetic appeal of the final product.

In addition to sensory aspects, the nutritional composition of cakes is significantly enriched through the inclusion of green leafy vegetables. Vitamins and minerals, such as vitamins A, C, and K, iron, calcium, and potassium, contribute to the overall nutritional profile of the baked goods. A study by Toker and Turker (2019) investigating the effects of green amaranth powder on cookies provides insights into how the nutritional content of the cake can be augmented, thereby aligning with the rising consumer demand for nutrient-dense and health-promoting food options.

However, the amalgamation of green leafy vegetables into cake recipes poses distinct engineering challenges. Achieving a uniform distribution of vegetable matter throughout the batter is critical to ensuring that each bite delivers a consistent flavor profile. Moreover, the leavening process may be affected, requiring careful consideration of rising agents to maintain the desired cake structure. Research in the broader context of gluten-free bread formulations by Sahin and Sumnu (2006) underscores the intricate engineering considerations involved in maintaining the quality of baked goods when unconventional ingredients are introduced.

2.5 Sensory evaluation of cake incorporated with green leafy vegetables

Cereal products are consumed daily by the majority of the world population. The tendency of consumers for functional products has resulted in an increase in the development of different and healthier cereal products (Ayadi *et al*., 2009). The health-enhancing characteristics of plants such as green leafy vegetables, herbs, edible flowers, etc. in providing important components has led to their use in food products (Lebesi and Tzia, 2011). Green amaranth contains phenolic compounds (like chlorophylls and carotenoids), fibre, vitamins (vitamin A, B complex, C, and K), and minerals (calcium, magnesium, potassium, iron, phosphorus, sodium, copper, sulphide, manganese, and zinc) (Toledo *et al*., 2003 and Çıtak Sönmez, 2009). For this reason, the use of green amaranth as a natural coloring agent and as a functional food ingredient, has a high potential for developing biologically active foods such as cakes. In addition, the consumption of leafy vegetables (green amaranth, cabbage, purslane, celery, etc) has been increasing especially as a result of changes in the consumer lifestyle. Green amaranth (Amaranthus viridis L.), which can be consumed as raw, boiled, canned, frozen, in bakery products, soups, etc. is a cool season annual vegetable (Ozkan *et al*., 2007, Citak and Sonmez 2009, and Çalışkan Koç and Dirim, 2017)

The sensory evaluation of green leafy vegetables incorporated into cakes marks an intriguing exploration into the fusion of health-conscious culinary practices and delightful gustatory experiences. As the culinary landscape evolves, the inclusion of green leafy vegetables in cakes not only introduces a nutritional boost but also challenges traditional notions of flavor profiles, textures, and overall sensory appeal. One of the primary sensory aspects influenced by the integration of green leafy vegetables is the taste profile of the cake. The natural flavors of vegetables such as green amaranth, kale, or Swiss chard can impart a unique and earthy undertone to the cake, presenting an opportunity for a harmonious blend of sweetness and vegetal notes. The sensory experience, therefore, extends beyond the conventional sugary indulgence, offering a more nuanced and complex flavor profile that resonates with individuals seeking diverse taste experiences. Research studies, such as those exploring the sensory attributes of vegetable-enriched baked goods, provide valuable insights into how the inclusion of green leafy vegetables can shape taste perceptions.

Texture is another pivotal sensory parameter affected by the addition of green leafy vegetables. The inherent moisture content and fibrous nature of these vegetables contribute to the overall mouthfeel of the cake. The challenge lies in achieving a balance that enhances the moistness of the cake without compromising its structural integrity. Sensory evaluations, often conducted through trained panels or consumer testing, play a crucial role in determining the optimal texture that aligns with consumer preferences. Visual appeal is not to be overlooked in the sensory evaluation of vegetable-incorporated cakes. The vibrant green hues introduced by chlorophyll-rich vegetables create an enticing visual spectacle. The adage "we eat with our eyes first" holds true, and the incorporation of green leafy vegetables adds a visual element that communicates freshness and healthfulness. Researchers often use visual assessments as part of sensory evaluations to understand the impact of color on overall product acceptance.

Beyond taste, texture, and appearance, olfactory sensations contribute significantly to the sensory evaluation of cakes. The aroma emanating from a vegetable-enriched cake can evoke a sense of natural freshness and contribute to the overall sensory experience. Understanding how aroma profiles change with the addition of green leafy vegetables allows bakers and researchers to fine-tune formulations for optimal olfactory appeal.

The sensory evaluation of cakes featuring the incorporation of green vegetables encompasses a nuanced exploration of multiple dimensions. Visually, the cake's vibrant green hues, a result of the added vegetables, contribute to its aesthetic appeal. The aroma introduces subtle vegetal notes, providing a complex olfactory experience. The flavor profile, influenced by the green vegetables, ranges from mild to pronounced, requiring a delicate balance to harmonize with the sweetness of the cake. The moisture content from vegetables, especially those high in water, enhances the cake's texture, ensuring a moist and tender crumb. The crumb structure, influenced by vegetable fibres, plays a role in determining the cake's density and mouthfeel. Ultimately, the sensory evaluation revolves around the overall palatability and enjoyment, considering how well the vegetable elements integrate into the traditional cake experience. This innovative twist not only adds an element of surprise but also caters to diverse palates, making it a captivating and unique addition to the world of baked goods.

2.5 Effects of incorporation of green leafy vegetable in bakery products

The infusion of green vegetables into cake recipes produces a multifaceted array of effects that extend from nutritional enhancements to sensory delights. Nutritionally, green vegetables like zucchini or green amaranth introduce essential vitamins and minerals, enriching the cake with nutrients such as vitamins A, C, and K, as well as iron and calcium. This not only contributes to the overall nutritional value of the cake but also aligns with the preferences of health-conscious consumers. The inclusion of vegetables also adds dietary fibre, promoting digestive health and providing a wholesome component to the indulgent treat. Visually, the incorporation of green hues imparts a natural and appealing aesthetic, complementing the traditionally sweet and decadent nature of cakes. The taste profile is elevated with a subtle yet distinctive flavor, adding depth and complexity to the overall sensory experience. Furthermore, the moisture content from the vegetables enhances the cake's texture, resulting in a moist and tender crumb. From a market perspective, vegetable-infused cakes present a unique selling proposition in the competitive baking landscape, appealing to those seeking innovative and health-conscious dessert options. In essence, the incorporation of green vegetables into cakes not only caters to nutritional considerations but also elevates the sensory and market appeal of this beloved dessert

From a nutritional standpoint, the incorporation of green amaranth leaf powder elevates the cake's health quotient significantly. Green amaranth is a powerhouse of vitamins, including A, C, and K, as well as essential minerals like iron and calcium. The addition of green amaranth leaf powder not only imparts these valuable nutrients to the cake but also enhances its overall nutritional density. This effect aligns with the growing demand for foods that contribute to well-rounded and health-conscious diets. Sensory aspects are profoundly influenced by the inclusion of green amaranth leaf powder. The distinct earthy and slightly sweet flavor profile of green amaranth adds depth to the cake's taste, creating a nuanced and well-balanced fusion. Studies on the sensory evaluation of baked goods with green amaranth powder often highlight the potential for a pleasant and unique flavor experience, showcasing how this leafy green can contribute to the culinary landscape.

Texture, a critical element in the enjoyment of cakes, undergoes notable changes with the incorporation of green amaranth leaf powder. The fine texture of the powder blends seamlessly into the cake batter, contributing to a moist and tender crumb. This effect is particularly pronounced in studies exploring the use of green amaranth powder in cakes, where the moisture content and fibrous nature of green amaranth enhance the overall mouthfeel, creating a delightful and distinctive texture. Visually, the incorporation of green amaranth leaf powder introduces an appealing green hue to the cake. This visual transformation not only adds an element of freshness and vibrancy but also communicates the infusion of healthful ingredients. The visual effects of green amaranth leaf powder in cakes resonate with consumers seeking visually appealing and nutritious food options.

Beyond the immediate effects on nutrition, taste, texture, and appearance, incorporating green amaranth leaf powder into cakes contributes to a broader narrative of culinary innovation and sustainability. Utilizing green amaranth leaf powder as an ingredient aligns with the goal of minimizing food waste and maximizing the use of nutrient-dense ingredients in creative ways.

2.7 Importance of bakery products

People of all ages prefer bakery products, because of their taste, colour and ease in indigestion. They eat and serve different bakery products in parties and festivals. Celebrating any moment of happiness is incomplete without bakery products. Bakery products are becoming prominent day by day. They are very popular because of their taste and easy digestabilities. Bakery items are usually loved by all. Nowadays individuals have virtually no time to invest in making breakfast; it is the breads, buns or biscuits which have replaced the conventional breakfast dishes. Honouring any occasion of pleasure is incomplete without bakery items. They take a good share of snacks and are therefore are abundantly available. (Stevenrio, 2012). Bakery products have the advantage of being ready to serve and ready to eat. Their durability, taste, and eye- catching appeal make the products popular. Bakery products, once considered as a sickman's diet have now become essential food items of the vast majority of people in India. Breads, buns and biscuits have become popular among all sections of the population, irrespective of age groups and economic conditions. The cause for rise in popularity of baked products is mainly due to urbanization. This has called for an increased demand for convenience products, at reasonable costs, with greater nutritional qualities and variety with different textural and taste profiles (Saurabh, 2013). Baking industry offers a large variety of products. However, its stability faces great challenges due 17 to the heavy competition among the producers. Bakery products are the easy, readymade food items which are easily available on demand. These are available since decades, but now the liking for these items is increasing rapidly. In the present era, there are large varieties of bakery products available in the market. The popular bakery products are classified as discussed below. Cake is a new bakery product compared to the other bakery products. It was earlier famous in the Western countries but now it is becoming popular in other parts of the world too. In olden times it was considered the food of rich homesteads and was mostly popular among Christians. But with modernization, it is gaining popularity among all the communities. It is a perishable product made for wheat flour, cream, gel, sugar and milk. It is of two types viz., egg cakes and fruit cakes. Egg is mostly used in this to make it fluffy. Egg cakes are more perishable than fruit cakes. Cakes are used in parties and on all happy occasions. Mostly the young generations have developed the taste for this item. But the use of cakes is mostly confined to urban areas. These are not very popular in rural areas due to its low accessibility, as it is not available everywhere, except in big bakeries. Plant and machinery used in preparing cakes is expensive and needs good investment. Its scope is increasing in India also (Karaoglu *et al*., 2009)

2.8. Need for improving quality of flour used in baking

In this fast age of busy work schedules; people are consuming more processed food items to suit their tight time schedules. As a generation endowed with advanced technology and greater conveniences, people are eating more processed and fast foods than ever. These unhealthy eating habits have resulted in the increase of non-communicable diseases (NCDs) like diabetes, obesity and some types of cancer (Sharma *et al*., 2012). The number of diabetic and hypertensive patients in India is expected to increase to 69.9 and 213 million respectively by 2020. Cardio vascular diseases (CVD) will be the largest cause of disability and deaths in India. Kerala is emerging 18 as the "capital" of life style diseases in India with high prevalence of hypertension, diabetes, obesity and risk factors for heart diseases reaching levels comparable to those in western countries (Reddy *et al*., 2006). People are becoming aware of this serious issue of life style diseases since the last few decades. Thus functional foods have become an essential component of human diet to prevent and cure such life style disorders (Jisha *et al*., 2008). Recently, consumer awareness of the need to eat high quality and healthy foods – known as functional foods has increased. Functional foods are foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements. Health consciousness of consumers has increased over the years. Functional foods have attracted all sections of the population, which have been proved to prevent and control degenerative diseases. There is a trend to produce specialty breads from whole grain flour and other functional ingredients which are known as health breads or functional foods 'Iron calla' the bread made from refined flour does not possess any of these qualities and in fact is found to be harmful in the long run. (Ndife *et al*., 2011). Supplementing staple foods with legumes rich in lysine have been suggested to improve the nutritional status of children in developing countries. (FAO/WHO, 2003).

2.9 Scope of composite flour

Composite flour can be incorporated in bakery and confectionary products, extruded products, chapattis, breakfast items, health mixes and many more popular food items. Composite flour is a blend of various ingredients which is mostly intended to replace wheat flour totally or partially in food products. The extent to which wheat flour could be replaced by other vegetable flours naturally depended on the nature of the products to be baked. Incorporating locally available flours into food products would help to reduce the import of wheat in developing countries. Hence these governments are giving more focus on this aspect Food and Agricultural Organization (FAO) 19 initiated this 'composite technology 'in 1964, by promoting indigenous crops like cassava, yam, maize, and many others for substituting wheat flour. The sensory qualities of the composite flour based bakery products were found to be on par with the conventional products. Moreover, this concept has brought in immense variety in baked products. Mostly the processed foods are prepared from refined wheat flour which is not healthy reported from scientific studies. More cereals and less protective foods in the diet, negatively affects nutritional status. Cereal based foods are deficient in micro nutrients. Nutrient rich materials have to be blended with nutrient deficient materials. Also, this improves the functional quality of the products. Cereal based foods are deficient in micro nutrients. The deficiency of lysine and threonine in wheat flour can be made of by the composite flours. For example; the protein quality of both the cassava-soya and the cassava-groundnut breads is higher than that of common wheat bread (Ojure and Quadri, 2012). Nutrient rich materials have to be blended with nutrient deficient materials. This also improves the functional quality of the product. The ingredients that can be used for preparation of composite flour are, cassava, sweet potato, taro, maize, rice, sorghum, yam, ragi, oats, barley, buck wheat, pulses, chick- pea, cowpea, mung bean, vegetables like pumpkin, bread fruit and fruits like papaya and jackfruits, as seen reported in literature. The research interest in composite flour has been on the rise in the recent past, with the aim of finding non-wheat alternatives and, thus reducing the non-wheat producing country's dependence on imported wheat (Bugusu *et al*., 2001).

2.10. Food fortification

The FDA established its food fortification policy in 1980. This policy was guided by 6 basic principles. The nutrient intake without fortification is below the desirable content for a significant portion of population, the food being fortified is consumed in quantities that would make a significant portion of population, the additional nutrient intake resulting from fortification is unlikely to create an imbalance of essential nutrients, the nutrient added is stable under proper conditions of storage and use, the nutrient is physiologically available from the food to which it is being added, there is reasonable assurance that it will not result in potentially toxic intakes (Crane N T, 1995). In 1923, Switzerland was the first country to fortify salt with iodine to prevent goitre and cretinism. This initiative was later followed by US in 1930. In 1932, the fortification vitamin A and D to dairy products. In 1938, voluntary enrichment of flours and breads with niacin and iron was initiated to reduce the 15 incidences of pellagra and iron-deficiency anaemia (Hoffman, 1997). In 1974, fortification of sugar with vitamin A was initiated in Guatemala. Sugar was selected because researchers realized that no other staple food reaching all target groups. This programme reduced the prevalence of anaemia. In 1998, US include folic acid in the fortification of wheat flour, in order to prevent the high prevalence of pregnancies affected by spina bifida and other neural tube defects (Nilson, 1998). Food fortification for decades been used to improve the nutritional quality of food supply. The rare occurrence of rickets in children, the classical vitamin D deficiency disease, so widespread in many industrialised countries at the turn of the century, has in part been ascribed to fortification programmes. An increased intake of vitamin D through fortification of foods (milk and oils) should therefore benefit bone health (Ovesen, 2004). Food fortification is currently implemented as a public health strategy to combat iron deficiency in many countries, either by fortification of staple foods such as milled cereal flours to reach a large proportion of population or by targeted approaches based on fortification of products consumed by vulnerable population groups, e.g., fortified commercial infant foods. Other approaches have been developed to reach individuals, who do not have access to centrally produced foods by providing micronutrients in sachets, crushable tablets, and spreads for 'in-home fortification' (Davidson, 2013). Diet based strategies are considered to be one of the most efficient and sustainable ways to overcome iron and vitamin A deficiencies. Fortification of bakery products is given priority in recent times as more number of bakery items are liked and consumed by quite a number of people. Cake is an ideal vehicle for fortification as it is a popular snack or dessert of all age groups especially children and adolescents. As cakes are soft in texture, it is suitable for old people to consume without any difficulty of chewing. Cakes are fun to eat and are consumed in events such as gatherings, seminars, party as they have better appeal, taste, satiety and convenience, however they are low in micronutrient content but high in fat. Hence, fortification using locally available under exploited yet nutritionally rich food is a good means of enhancing the micronutrient content of cakes (Narayanan, 2015). 16 Food fortification has been shown to be an impactful approach to improve micronutrient status and related functional outcomes for some nutrients in some food, but there are still calls to strengthen the evidence base, particularly with programmatic evidence. Using impact pathways to guide evaluations and prioritizing impact assessment in programs with appropriate design (i.e., in populations with potential to respond and appropriate food vehicles/fortificants) and implementation (i.e., compliance monitoring and enforcement, high coverage in populations with potential to respond) could substantially increase the quality of evidence for food fortification (Neufeld, 2018).

Fig. 2.1. Fresh and dried amaranth leaf powder

CHAPTER III

MATERIALS AND METHODS

The present study entitled "Development and quality evaluation of cake fortified with amaranth (*Amaranthus viridis*) leaf powder" was conducted as three experiments and the methodology adopted is discussed under the following heads.

3.1. Selection of raw ingredients for cake

3.2. Development of cake fortified with Amaranthus viridis leaf powder

3.3. Nutritional and sensory characteristics of cake

3.1. Selection of raw ingredients for cake

3.1.1 Refined wheat flour

Refined wheat flour was procured from local market which is located at Tavanur.

Fig.3.1. Refined wheat flour

3.1.2. Processing of green amaranth leaves powder

Mature green and disease-free (*Amaranthus viridis*) leaves were collected from the market. The harvested leaves were scrubbed and spread on a sheet with even thickness at room temperature for initial drying. Afterward, the leaves were dried out using heat pump drying method and drying characteristics were noted. 50 g of Green amaranth leaves were distributed uniformly on trays in a cabinet at 60°C for 3 hours. The dried leaves were milled using a laboratory miller and sieved (1 mm sieve size).

Fig 3.2. Cabinet drier

3.1.3. Processing of other ingredients

Egg, Cake gel, Sugar, Salt, Sunflower oil, Milk, Flavour (Vanilla) and Baking powder was also selected for the application of composite flours to cake. The process of cake involves mixing the ingredients of eggs (103 g), sugar (100 g), and Sunflower oil (30 g) together, by using a mixer for 10 mins until the mixture becomes thick and stiff.

3.2. Development of cake fortified with amaranth (*Amaranthus viridis*) leaf powder

Cake fortified with (*Amaranthus viridis*) leaf powder were formulated by using the ingredients: Refined wheat flour, Green amaranth leaf powder, Egg, Salt, Milk, Cake gel, Sugar, Sunflower Oil, Flavour (Vanilla) and Baking powder. Totally five combinations of cake were worked out and from this the best treatment was identified through sensory evaluation and was selected for quality analysis. The various treatments proposed are depicted in Table 3.1.

Table.3.1. Composition of ingredients for standardization of amaranth leaf powder incorporated cake

S. No.	Treatment	Egg (Nos.)	Sugar (g)	Amaranth leaves powder (g)	Refined wheat flour (g)
1	T0	2	100	-	100
2	T1	2	100	2.5	100
3	T2	2	100	5	100
4	T3	2	100	7.5	100
5	T4	2	100	10	100

3.2.1 Standardization of cake recipe

Ingredients

- Refined wheat flour + Green amaranth leaf powder (100g) in varying composition
- Egg -2 no's
- Milk -3 table spoon
- Sunflower oil- 30g

- Sugar -100g
- Salt-1 pinch
- Flavour (Vanilla)- ¾ teaspoon
- Baking powder - 1 teaspoon
- Cake gel-1 tea spoon

Preparation of cake

- Pre heat the oven at 180°C for 10 minutes
- The egg was beaten for 10 minutes until it forms a peak
- The flours along with baking powder and cake gel was sifted
- A bowl was taken and the sugar was mixed with sunflower oil to a smooth mix
- To this sifted flour is added in little amount along with the beaten egg foam with continuous beating
- To the smooth cake mix add the flavour and milk and beaten for a minute.
- The mixture is transferred to a mould which has been coated with butter and placed inside the preheated oven.
- Bake the cake at 170°C for 15 minutes
- Take the cake from oven and allow it to cool for 10 minutes and then transfer it to plate.
- The cake can be cut and used.

Weighing of ingredients as per recipe

↓

Sifting of flour and other powdered ingredients

↓

Creaming of sunflower oil and sugar till it becomes soft, light and fluffy

↓

Addition of flour and other ingredients to make dough

↓

Addition of milk

↓

Addition of vanilla essence

↓

Resting of dough for 15min

↓

Sheeting of dough and cutting is carried out using
mould on baking trays

↓

Baking at 180°C for 20min

↓

Cooling

↓

Packaging

↓

Labelling

↓

Storage

Fig.3.3. Preparation of green amaranth leaf powder incorporated cake

3.3. Nutritional and sensory characteristics of cake

3.3.1. Sensory evaluation

Sensory evaluation has an essential role in new product development with regard to its acceptability. The developed cake was presented to thirty or ten semi trained panellists. They evaluated the sensory characteristics viz; colour, appearance, flavour, texture, taste on a score card using a 9-point hedonic scale. The scores allotted were analysed using statistical procedures to obtain a suitable conclusion. Totally five combinations of cake were worked out and from this the best treatment was identified through sensory evaluation and was selected for quality analysis.

3.3.2. Nutrient analysis of the selected cake

Nutrient as well as chemical composition analysis refers to the process of determining the nutritional and chemical components in foods and food products. The selected combination of cake and the control cake were analysed for nutrients as well as chemical components using standard procedures.

3.3.2.1. Proximate composition

The proximate composition of foods including carbohydrate, moisture level, fibre content, ash content, colour, water activity and antioxidant has done. This assessment is applicable in the food industry for product development, quality control or regulatory purposes.

3.3.2.1.a. Total carbohydrate

In the present study, the total carbohydrates of selected cakes were estimated by using anthrone reagent and incubating the samples in boiling water bath and recording the absorbance at 630 nm using a spectrophotometer against a blank reagent according to the method described by Hedge and Hofreiter (1962).

Plate.3.1. Spectrophotometer

3.3.2.1.b. Moisture content of the cake

Moisture content is one of the most commonly measured properties of food materials. Stability and quality of a food product depends upon the moisture content present in it. Moisture content was determined using a digital infrared moisture analyser. The equipment determines the moisture of a sample by heating and drying it with infrared irradiation and displays the moisture content from changes in mass due to evaporation.

Plate.3.2. Infrared moisture analyser

3.3.2.1.c. Fibre content

Crude fibre content was determined as per the method described by (Maynard, 1970). The dried sample was taken in the pre weighed glass crucible (W1) it was placed in crucible holder with the glass extractor. 150 ml of pre heated 1.25% H_2SO_4 was added in the extractor and the contents are boiled for 30 mins at 500˚C and 30 mins for 400˚C. The acid residue was drained out from the extractor through fibre flow system. The residue was washed with distilled water. Then 150 ml of pre heated 1.25% NaOH added and digested for 30 mins at 500˚C and 30 mins at 400˚C. Then the residue was washed with distilled water and dried for two to four hours at 100˚C, cooled and weighted.

$$\text{Crude fibre (\%)} = \frac{(W_3 - W_2)}{W_1} \times 100$$

Where,

W1= Weight of sample used

W2 = Weight of crucible

W3 = Weight of residue with crucible

Plate 3.3. Crude fibre analyser

3.3.2.1.d. Ash content

A high temperature muffle furnace capable of maintaining a temperature between 500-700°C was used to determine ash content. Water and other volatile materials were vaporised and organic substances were burned in the presence of oxygen in the air to carbon dioxide, water and nitrogen. The weight of crucible with the sample was noted before and after burning. The percentage of ash was calculated using the equation;

% of ash = (W2-W1)/W3*100

Where,

W1= weight of crucible

W2= weight of crucible with ash

W3= weight of sample

Plate.3.4. Muffle furnace

3.3.2.1.e. Colour

The colour of the cake was found using a Hunter lab colour flex meter (Hunter Association laboratory, Inc., Reston, Virgina, USA; model: Hunter Lab's Colour Flex EZ) which is shown in Plate 3.5. The Hunter lab's colour flex spectro calorimeter consists of measurement (sample) port, opaque cover and display unit.

The principle of working is by measuring the energy reflected from the sample across the entire visible spectrum, done by focusing the light. The three dimensional scale L*, a* and b* values were used for colour measurement. The luminance (L*) forms the vertical axis, which indicates light - dark spectrum with a range from 0 (black) to 100 (white). In the same way, a* indicates the green - red spectrum with a range of - 100 (green) to + 100 (red) and b* indicates the blue - yellow spectrum with a range from – 100 (blue) to + 100 (yellow) dimensions respectively (Reddy *et al*., 2014).The instrument was standardised before placing the sample by placing black and white tile provided with the instrument. A transparent glass cup filled with sample was placed over the port of the instrument and an opaque cover which act as a light trap to exclude the interference of external light was placed over the cup. Colour was calibrated by fixing the definite colours like white and black tiles. After calibration, the sample was placed over the port and values of 'L*', 'a*' and 'b*' were recorded.

Plate.3.5. Colorimeter

3.3.2.1.f. Water activity (a_w)

Water activity is used to predict the stability of the product with respect to microbial growth, chemical and biological reaction rates and physical properties during storage. Aqua Lab series 3 water activity meter (M/s Aqua lab, USA) was used to obtain the water activity of green amaranth cake. Water activity is measured by equilibrating the liquid phase water in the sample with the vapour phase water in the headspace and measuring the relative humidity of the head space. The water activity of green amaranth cake was carried out using Aqua lab water activity meter (M/s. Aqua Lab, U.S.A; model: Series 3TE) which is shown in Plate 3.6. The green amaranth cake was filled in the disposable cups of the water activity meter and the sample drawer knob is turned to OPEN position. The product was then placed in the sealed chamber and turned the knob to READ position. The water activity of the sample was recorded with respect to atmospheric temperature.

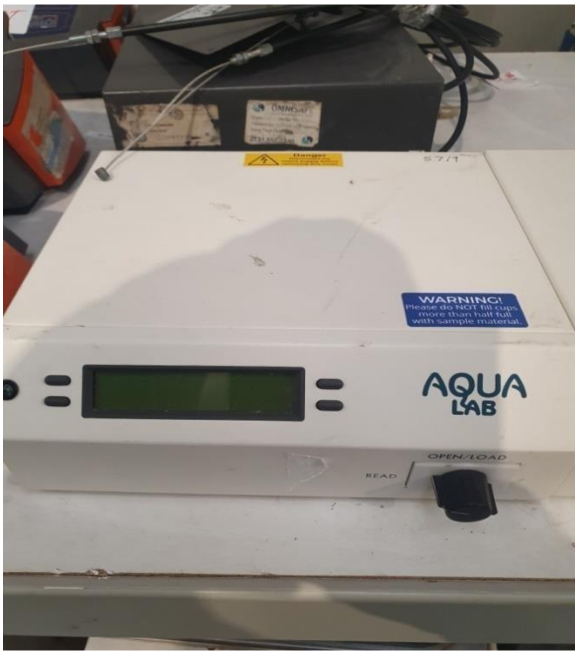

Plate. 3.6. Water activity meter

3.3.2.1.g. Antioxidant activity (DPPH (2, 2-diphenyl-1-picrylhydrazyl) free radicals scavenging activity)

The antioxidant activities of the raw and baked cake extracts were measured in terms of hydrogen donating or radical scavenging ability, using the DPPH (2,2- diphenyl-1-picrylhydrazyl) method (Saharan *et al*., 2017). A methanolic solution (0.1 ml) of the sample extracts were added to 3.9 ml (0.025 g/L) of DPPH solution. The solution was incubated at room temperature for 60 min and the decrease in absorbance at 515 nm was determined at the end of incubation period with a spectrophotometer. Radical scavenging activity was expressed as the inhibition percentage of free radicals by the samples and was calculated using the following equation:

$$\text{DPPH radical scavenging activity (\%)} = \frac{\text{Control OD - Sample OD X 100}}{\text{Control OD}}$$

Where, (OD= Optical Density)

plate. 3.7. spectrophotometer

3.3.3. Storage studies

Shelf-life studies can provide important information to product developers enabling them to ensure that the consumers will see a high-quality product for a significant period of time after production. Just as microorganisms can grow during storage, other changes too may occur in the composition of the food. This deterioration may make the food unacceptable to the consumer. Due to such cases the changes in the food during storage may make it unsafe, due to the nature of the compounds formed. To observe the keeping quality, the product was packed in PE covers and kept for shelf-life analysis for one month.

CHAPTER IV

RESULTS AND DISCUSSION

Fortification of food is widely practiced in several foods to increase the content of essential micronutrients, to enhance the nutritional quality of the food, and to ensure higher health benefits with minimal risk to health. However, it is imperative to ensure that the fortified food and fortificant must be compatible and the fortificant must be readily available and accessible without producing a substantial change in the fortified meal's sensory characteristics or consumer acceptability. Under the current experiment, locally available green amaranth powders were used as fortificant to develop fortified cake and their nutritional, sensory evaluation, and consumer acceptability were assessed. The cakes became darker in colour than the unfortified cake with the increase of amaranth leaf powder concentration in the formulations. The darker colour was expected with the addition of amaranth leaf powder in the formulations, as Green amaranth leaves contain higher concentrations of chlorophyll and are naturally dark green in colour, which causes the undesirable green tint in the fortified cakes. A similar colour change trend was also reported in several studies in cookies and snacks due to the chlorophyll concentration of the leaves used for fortification. This dark colour can adversely affect the acceptability of the amaranth leaf powder fortified cake by consumers, as it is more attractive in terms of appearance. However, nutritional and other sensory attributes of amaranth leaf powder fortified cake may outweigh that limitation as people are more concerned today about health benefits rather than appearance.

4.1. Sensory attributes of fortified cake

The mean sensory attributes of the amaranth leaf powder fortified cakes are presented in Table.4.1. The sensory qualities varied significantly among the cakes in terms of colour, body &texture, appearance, taste, flavour, mouth feel and overall acceptability. However, the shape did not differ significantly among the cakes. The colour of the cake changed from a light brown (control) to a dark-greenish colour with the concentration of amaranth leaf powder increased in the formulation. Among the cakes, maximum sweetness and flavour value was recorded from the T1, which was significantly higher over the non-fortified control (T0). The maximum consumer acceptability was recorded in T4. The sensory assessments indicated that the control cake sample had the highest consumer acceptance compared with their respective cake samples containing amaranth leaf powder and refined wheat flour. The lower consumer acceptance value may be due to the darker colour & flavour of the fortified cakes. These findings are consistent with earlier research, which indicated a small reduction in overall acceptability as amaranth leaf powder increased (Roni, 2021; El-Gammal, 2016). However, the cake fortified with 2.5g amaranth leaf powder rated similar in almost all the sensory attributes evaluated, which is also statistically similar to that of the unfortified control. Food products supplemented with amaranth leaf powder were generally acceptable, according to (Kolawole *et al*, 2013) but reported acceptance dropped dramatically as amaranth leaf powder concentrations were increased for the cakes. The cake which is fortified with 7.5g amaranth leaf powder and 100 g refined wheat flour shows similar acceptability as that of the control cake. The texture of the cake was found to be of less acceptability to consumer because of the lack of binding agent. Thus, a fortified cake having a good overall acceptability can be made to overcome the malnutrition.

Fig.4.1. Amaranth leaf powder incorporated cake

Table.4.1. Sensory evaluation of cake samples

Characteristics	T0	T1	T2	T3	T4
Appearance	8.5	7.7	7.7	7.7	7.4
Color	8.1	7.6	7.7	7.7	7.3
Flavor	8.3	6.6	7.0	7.0	6.9
Texture	8.3	7.2	7.3	7.5	6.5
Taste	8.4	6.6	6.8	7.3	6.2
Mouth feel	8.3	7.0	7.1	7.4	6.2
Overall acceptability	8.5	6.9	7.5	7.6	6.1

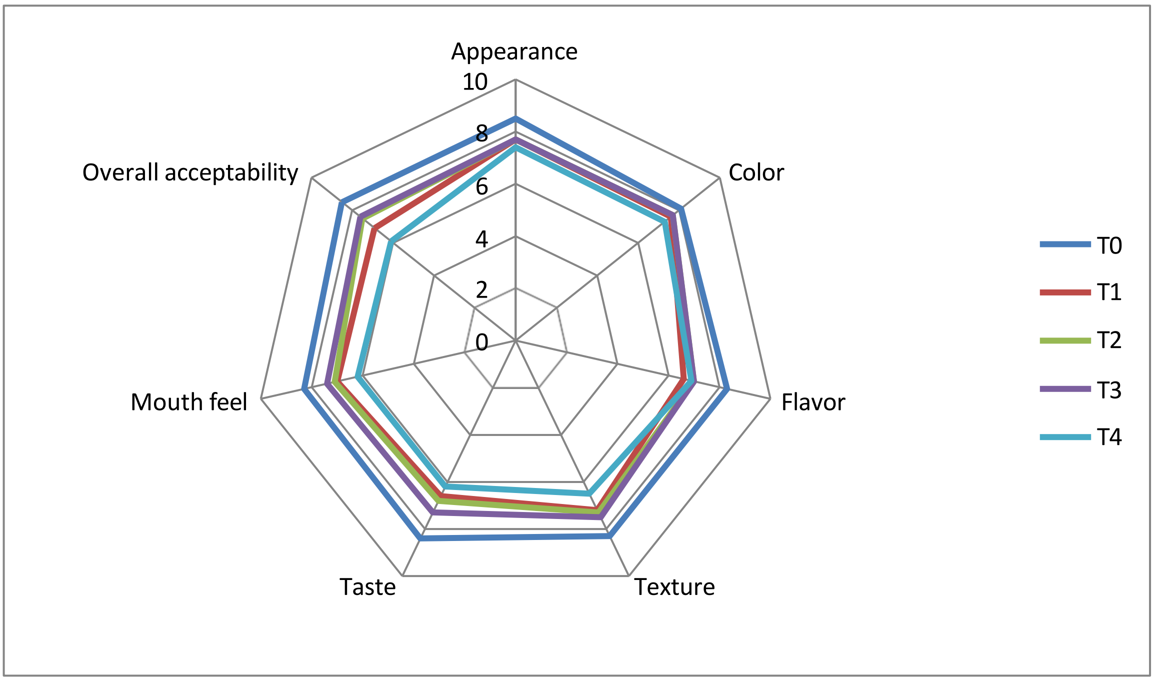

Fig.4.2. Sensory evaluation of cake samples

4.2. Proximate composition of the amaranth leaf powder incorporated cake

Proximate composition of the developed cake fortified with amaranth leaf powder has been done. The moisture content of cake slightly increased from 14.56 to 15.45% with the increased substitution of amaranth leaf powder in the cake. Studies shown that, the safe moisture content of cake vary from 15-30%, so that our product will be shelf stable for at-least 1 month. The ash content significantly increased as the substitution level of amaranth leaf powder increased

.

T0 T1 T2

T3 T4

Fig.4.3. Green amaranth leaf powder incorporated cake

4.2.1. Total Carbohydrate

The total carbohydrate of cake found to be slightly higher for fortified cake (68g) than that of unfortified cake (58.2g). This may be due to the increase in fibre content with the addition of amaranth leaf powder. The absorbance values obtained from the experiment; glucose curve plotted to get the corresponding concentrations. From the concentration values, the final carbohydrate value was determined.

Table.4.2. Absorbance and concentration of Glucose

Absorbance	Concentration (mg/ml)
0	0
0.163	0.2
0.230	0.4
0.356	0.6
0.449	0.8
0.607	1.0

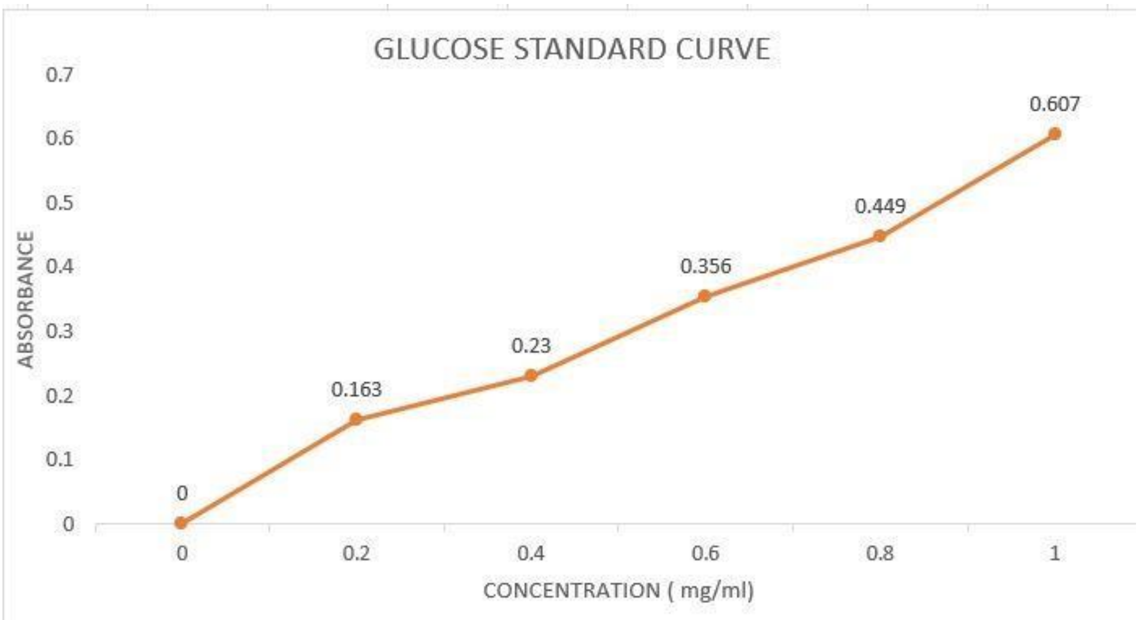

Fig.4.4. Glucose standard curve

Table.4.3. Carbohydrate content of amaranth leaf powder incorporated cake

Sample	Absorbance	Concentration (mg/ml)	Carbohydrate (%)
T0	0.208	0.340	68
T1	0.202	0.329	65
T2	0.188	0.305	61.1
T3	0.180	0.291	58.2
T4	0.176	0.284	56.8

Fig.4.5. Analysis of carbohydrate

4.2.2. Moisture Content

The moisture content found to be slightly higher for the unfortified (25.6%) than the fortified (23.2%). The safe moisture level of cake was reported to be 5- 17%. So, a shelf life of at-least 1 month is possible under refrigeration.

Table 4.4. Moisture content of amaranth leaf powder incorporated cake

Sample	Moisture content (%)
T0	25.6
T1	23.2
T2	21.8
T3	19.7
T4	18.4

4.2.3 Crude Fibre

Crude fibre of fortified cake was found to be 2.6 % whereas in unfortified cake, it is found to be only 0.35 %. Higher fibre content further provides numerous health benefits such as maintenance of bowel integrity, lowering blood cholesterol and controlling sugar levels (Aleixandre, 2016).

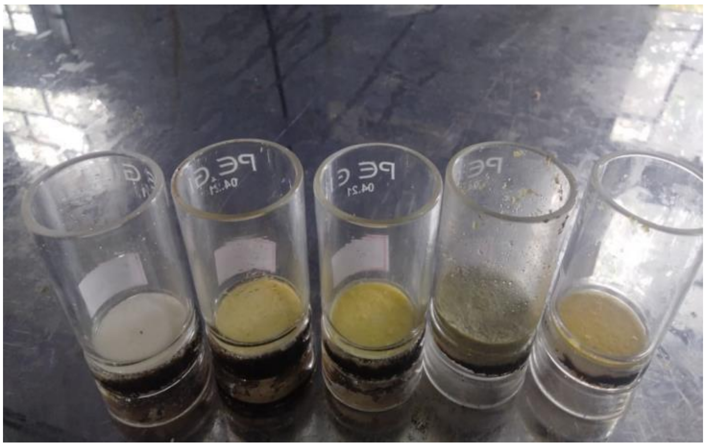

Fig 4.6. Analysis of crude fibre

Table 4.5. Crude fibre content of amaranth leaf powder incorporated cake

Sample	Fibre content (g)
T0	0.135
T1	0.160
T2	0.167
T3	0.173
T4	0.203

4.4. Ash Content

The ash content also shows an increasing trend as the amaranth leaf powder in cake formulation increased. The ash content of unfortified cake was found to be 2.3%, whereas, in the fortified cake, it was found to be 2.4%. Thus, the total mineral content increased with increase in amaranth leaf powder in cake.

Table 4.6. Ash content of amaranth leaf powder incorporated cake

Sample	Ash Content (%)
T0	2.3
T1	2.4
T2	2.6
T3	2.8
T4	2.9

4.5 Colour

The L* values of green amaranth cake is shown in Table 4.7. Only an insignificant difference was observed in the case of 'L*' values. The maximum L* value was observed for the T0 (65). Corresponding a* and b* values were observed as 1.833 & 20.1 respectively. Minimum L* value was observed for highest green amaranth concentration. Combination T4 (10%) showed minimum values of L*, a* and b* (41.7,- 4.73, 27).b* values exhibited significant effect with green amaranth concentrations.

Table 4.7. Colour values of content of amaranth leaf powder incorporated cake

Colour value	T0	T1	T2	T3	T4
L	65	57.6	48.89	44.8	41.7
a*	1.833	-2.63	-3.12	-3.43	-4.73
b*	20.1	24.23	25.42	26.1	27
ΔE	63.614	62.544	55.191	51.961	49.902

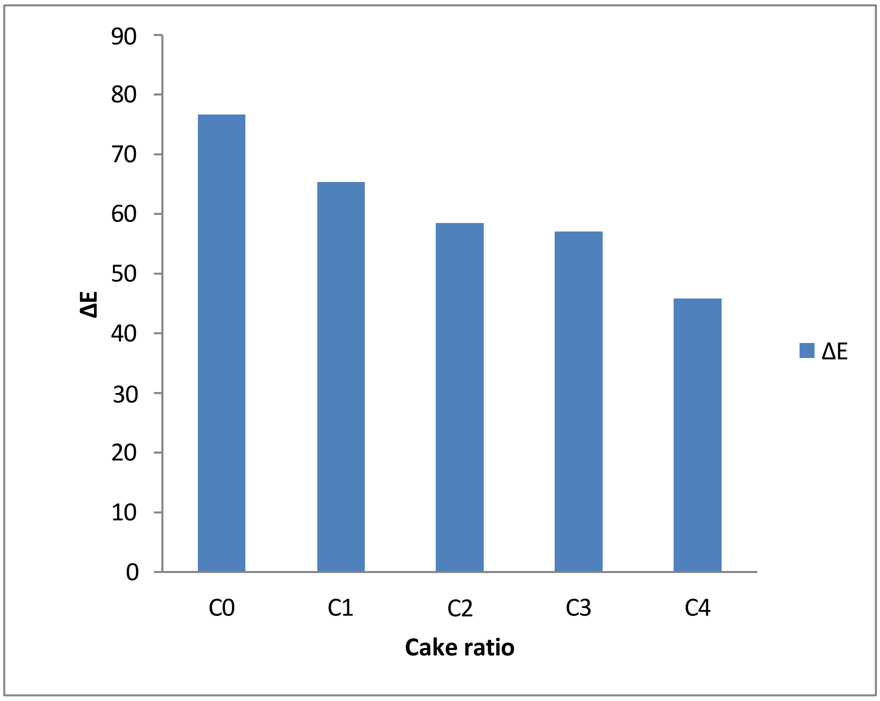

Fig 4.7. ΔE value of green amaranth leaf powder fortified cake

Table 4.8. Colour values of green amaranth leaf powder cake batter

Colour Value	T0	T1	T2	T3	T4
L	74.46	62.15	52.43	50.5	38.56
a*	2.466	-3.7	-4.6	-5.3	-5.4
b*	17.96	19.77	25.4	25.9	24.133
ΔE	76.635	65.323	58.439	57.001	45.808

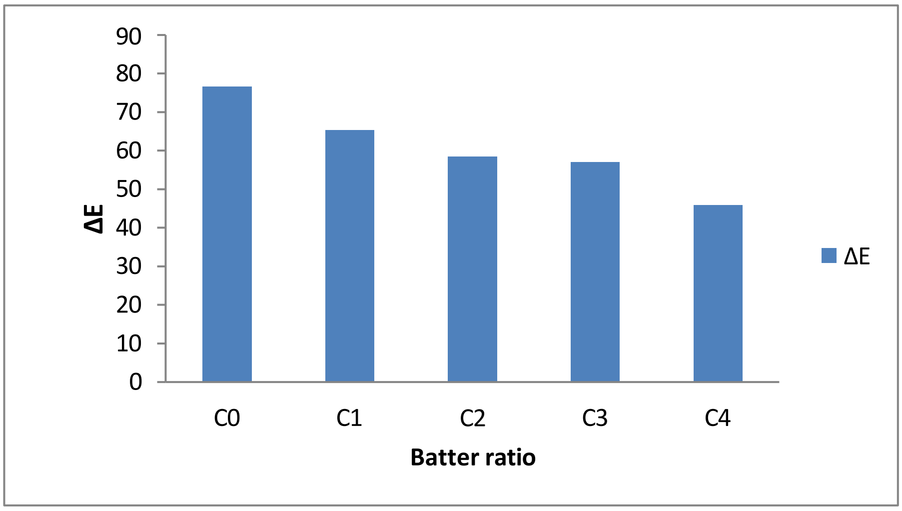

Fig 4.8. ΔE value of green amaranth cake batter

4.6 Water activity

The water activity values ranged from 0.894 to 0.857 (Table 4.9). Maximum water activity was obtained for T0 treatment and minimum for T2. Water activity variation was observed similar to moisture content. The low water activity may due to the increase in TSS content of the product. Abadio *et al*. (2004) stated that an increase in the maltodextrin concentration resulted decrease in the moisture content and water activity, mostly due to an improvement in total solids in the cake and decreased amount of free water for evaporation.

Table 4.9. Water activity of amaranth leaf powder incorporated cake

Sample	Water activity (a_w)
T0	0.894
T1	0.885
T2	0.873
T3	0.864
T4	0.857

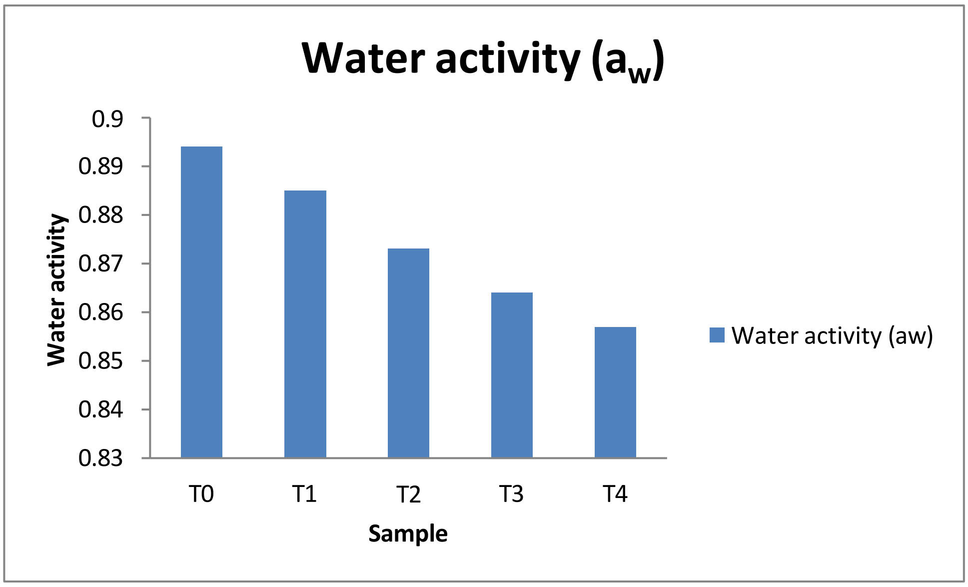

Fig 4.9. a_w value of green amaranth leaf powder incorporated cake

4.7 Antioxidant activity

Antioxidant activity of fortified cake was found to be 11.79 % whereas in unfortified cake, it is found to be only 2.94 %. Antioxidants help combat oxidative stress in the body, which is linked to various chronic diseases and enhance the shelf life of the cake by slowing down the oxidation of fats and preventing rancidity. It's worth noting that while adding green amaranth to a cake can contribute some antioxidants and nutrients, the overall healthiness of the cake depends on the entire recipe. Balancing ingredients and enjoying such treats in moderation is key to maintaining a well-rounded and healthy diet.

Table 4.10. Antioxidant activity of amaranth leaf powder incorporated cake

Sample	Antioxidant (DPPH %)
T0	2.949
T1	7.659
T2	9.6131
T3	11.796
T4	11.834

Table 4.11. Proximate composition of amaranth leaf powder incorporated cake

Sample	Carbohydrate (%)	Moisture (%)	Crude Fibre (g)	Ash Content (%)	Water activity (aw)	Antioxidant (%)
T0	68.0	25.6	0.14	2.3	0.89	2.94
T1	65.0	23.2	0.16	2.4	0.88	7.65
T2	61.1	21.8	0.17	2.6	0.87	9.61
T3	58.2	19.7	0.17	2.8	0.86	11.79
T4	56.8	18.4	0.20	2.9	0.85	11.83

CHAPTER V

SUMMARY AND CONCLUSION

Food fortification for decades been used to improve the nutritional quality of food supply. It is currently implemented as a public strategy to combat the micronutrient deficiency in many countries. Diet based strategies are considered one of the most efficient and sustainable ways to overcome the vitamin A deficiencies and all. Fortification on bakery products is given priority in recent times as more bakery items are liked and consumed by quite number of people. Cake is an ideal vehicle for fortification as it is a popular snack of all age groups especially children and adolescents. Green amaranth leaf fortification in food dishes has proven to be beneficial for human health. So-many studies show that, the fortification of green amaranth leaf powder added to daily food can increase the body weight of malnourished children. The addition of amaranthus viridis improves the anaemic status, indicated by an increase in the red blood cells, haemoglobin and haematocrit. The current study on the fortification of amaranth leaf powder in cakes can be used as a tool for preventing the malnutrition. The high fibre content and vitamin C content of amaranth leaf powder has increased the overall nutrient content of the cake.

The study on the development and quality evaluation of cakes fortified with Amaranthus viridis leaf involved several key steps. First, researchers formulated cake recipes with varying levels of green amaranth leaf powder to determine the optimal inclusion for nutritional enhancement. The cakes were then baked according to these formulations. Analytical techniques were employed to assess the nutritional content of both the control cakes and those fortified with green amaranth. This included measuring vitamins, minerals, and other key nutrients. The results revealed a significant increase in nutritional content in the cakes containing Amaranthus viridis, indicating successful fortification. Sensory evaluations were conducted to gauge consumer acceptability. Panellists assessed attributes such as taste, texture, aroma, and overall liking of the fortified cakes. The positive sensory feedback suggested that the addition of green amaranth did not adversely affect the organoleptic properties of the cakes. This is crucial for consumer acceptance and market viability.

The nutritional analysis showed the increased nutrition in cake as the amaranth leaf powder in the cake formulation increased. There is an increase in fibre content from 0.14 to 0.20%. 68g to 56.8g of total carbohydrate, as the amaranth leaf powder increased in the cake formulation. The ash content found to be increasing from 2.3% to 2.9% as amaranth leaf powder increased in cake. The sensory evaluation of the cake samples was also done to find out the overall acceptability of the cake. Fortification of cake with amaranth leaf powder resulted in enhanced nutritional, mineral, and vitamin A contents of the fortified cake. Sensory evaluation of the study revealed that the acceptability of the snacks decreased as amaranth leaf powder concentration was increased, but the cakes containing 7.5g amaranth leaf powder and 100g refined wheat flour were almost as acceptable as the control cake. Furthermore, the amaranth leaf powder enriched cake's high vitamin A content may help developing countries combat vitamin A deficiency. Overall, the research demonstrates that fortifying cakes with 7.5g amaranth leaf powder and 100g refined wheat flour can enhance nutrient content and contribute to better food and nutritional security.

Furthermore, the study considered the potential health benefits associated with the incorporation of Amaranthus viridis. Green amaranth is rich in various vitamins, minerals, and antioxidants, and its inclusion in cakes could contribute to a more nutritious and health-promoting product. In conclusion, the research demonstrated that fortifying cakes with Amaranthus viridis leaf is a feasible approach to enhance their nutritional profile. The study provided detailed insights into the formulation, nutritional impact, and sensory aspects of the fortified cakes, highlighting the potential for creating healthier baked goods. This information is valuable for both the food industry and consumers seeking nutritious alternatives in bakery products.

CHAPTER VI

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ABSTRACT

The incorporation of Amaranth (Amaranthus viridis) leaf powder into cake formulations represents an innovative approach to enhancing the nutritional profile and functional properties of baked goods. This study aimed to develop a cake recipe integrating varying concentrations of Amaranth leaf powder and to evaluate the impact on the quality attributes of the resulting product. The experimental design included the preparation of cakes with different grams of Amaranth leaf powder (0g, 2.5g,5g,7.5g and 10g) to determine the optimal balance between nutritional enhancement and sensory acceptability.

Quality evaluation was conducted through a series of assessments, including proximate analysis for nutritional content (ash, fiber, and carbohydrates), physical properties (texture, and color), and sensory attributes (taste, aroma, and overall acceptability) using a panel of trained sensory evaluators. Additionally, the antioxidant activity and shelf-life stability of the cakes were examined to ascertain the functional benefits conferred by the Amaranth leaf powder.

Results indicated that the incorporation of Amaranth leaf powder significantly increased the ash, fiber, and carbohydrates content of the cakes. Sensory evaluation revealed that cakes with up to 7.5g Amaranth leaf powder were highly acceptable in terms of taste and texture, while higher concentrations adversely affected the sensory qualities. The antioxidant activity was notably enhanced in cakes with Amaranth leaf powder, suggesting additional health benefits.

Overall, the study demonstrated that Amaranth leaf powder could be successfully incorporated into cake formulations to improve nutritional and functional properties without compromising sensory quality, particularly at an inclusion level of up to 7.5g. This innovation provides a viable strategy for producing nutritionally enriched bakery products that cater to health-conscious consumers.