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Sensory Evaluation and Nutritional Quality of Spaghetti Bolognese Through Herbal Fortification

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Abstract: This study explores the enhancement of the nutritional quality of Spaghetti Bolognese through the incorporation of culinary and functional herbs. The objective was to develop a herb-fortified formulation and evaluate its proximate composition, micronutrient content, antioxidant activity, and sensory acceptability. A standard Bolognese recipe was modified by incorporating basil, oregano, thyme, parsley, and garlic at optimized levels. Nutritional analysis revealed significant improvements in dietary fiber, vitamins (A, C, and K), and mineral content compared to the control sample. The herbal variant also exhibited higher antioxidant activity due to the presence of phenolic compounds. Sensory evaluation indicated high consumer acceptance with no adverse impact on taste, texture, or aroma. The findings suggest that herbal fortification is a practical and effective approach to transforming traditional pasta dishes into functional foods with enhanced health benefits. This study contributes to the growing field of culinary nutrition and functional food innovation.

Keywords: Herbal Fortification, Spaghetti Bolognese, Nutrition, Health Benefits.

Introduction: In recent years, there has been a significant shift in consumer dietary patterns toward healthier and more functional food options. This transition is largely driven by the rising prevalence of lifestyle-related disorders such as obesity, cardiovascular diseases, and diabetes, which are often linked to poor dietary habits and nutrient deficiencies. As a result, the concept of functional foods foods that provide health benefits beyond basic nutrition has gained considerable importance in both academic research and the food industry. One effective strategy within this domain is the reformulation of traditional dishes to enhance their nutritional value while maintaining their sensory appeal. In this context, the present study focuses on improving the nutritional profile of Spaghetti Bolognese through herbal fortification. Spaghetti Bolognese is a widely consumed pasta dish known for its rich flavor and balanced composition of carbohydrates, proteins, and fats. Traditionally prepared using refined pasta, minced meat, tomato-based sauce, and basic seasonings, the dish offers moderate nutritional value. However, it may lack sufficient dietary fiber, micronutrients, and bioactive compounds required for optimal health. Given its global popularity and adaptability, Spaghetti Bolognese serves as an ideal candidate for nutritional enhancement through the incorporation of functional ingredients. The addition of herbs, in particular, presents a promising approach to elevate both the nutritional and therapeutic value of the dish. Culinary herbs such as basil (Ocimum basilicum), oregano (Origanum vulgare), thyme (Thymus vulgaris), parsley (Petroselinum crispum), and garlic (Allium sativum) have been used for centuries not only for their flavor-enhancing properties but also for their medicinal benefits. These herbs are rich sources of vitamins, minerals, essential oils, and phytochemicals, including flavonoids and phenolic compounds. Scientific studies have demonstrated that these bioactive constituents possess antioxidant, anti-inflammatory, antimicrobial, and cardioprotective properties. Incorporating such herbs into everyday meals can therefore contribute to improved health outcomes and disease prevention. The use of herbs in food fortification

aligns with the growing trend of clean-label and natural ingredient-based product development. Unlike synthetic additives, herbs offer a natural and consumer-friendly alternative for enhancing food quality. Moreover, herbal fortification is cost-effective, widely accessible, and easily adaptable to different culinary traditions. In developing countries like India, where traditional knowledge of medicinal plants is deeply rooted, the integration of herbs into modern recipes presents an opportunity to combine indigenous wisdom with contemporary nutritional science. Another important aspect of herbal fortification is its impact on antioxidant activity. Oxidative stress, caused by an imbalance between free radicals and antioxidants in the body, is a major contributor to chronic diseases and aging. Herbs such as oregano and thyme are particularly high in antioxidant capacity, which can help neutralize free radicals and reduce oxidative damage. By incorporating these herbs into Spaghetti Bolognese, the dish can be transformed into a functional meal with enhanced health-promoting properties. In addition to nutritional benefits, sensory acceptability plays a crucial role in the success of any food product. The inclusion of herbs can significantly improve the aroma, taste, and visual appeal of dishes, thereby increasing consumer satisfaction. However, it is essential to optimize the quantity and combination of herbs to ensure that the enhanced nutritional value does not compromise the traditional flavor profile. Therefore, a balanced formulation is required to achieve both health benefits and sensory acceptance. This study aims to develop a herb-fortified version of Spaghetti Bolognese and evaluate its nutritional composition, antioxidant potential, and sensory characteristics. By comparing the fortified formulation with the traditional version, the research seeks to demonstrate the effectiveness of herbal incorporation as a strategy for nutritional enhancement. The findings are expected to contribute to the field of functional food development and provide practical insights for the food service industry, particularly in the context of promoting healthier menu options. The integration of herbs into traditional dishes like Spaghetti Bolognese represents a sustainable and innovative approach to addressing modern nutritional challenges. It not only enhances the health value of commonly consumed foods but also preserves culinary heritage, making it a viable solution for improving public health through diet.

Literature Review

The growing demand for healthier food options has led to an increased focus on functional foods and dietary modifications that enhance nutritional quality without compromising sensory appeal. One widely explored strategy in food science is the fortification of traditional dishes with natural ingredients rich in bioactive compounds. Among such dishes, Spaghetti Bolognese has gained attention as a suitable candidate for nutritional enhancement due to its global popularity and adaptable formulation. This literature review examines existing research on herbal fortification, functional foods, antioxidant properties of herbs, and their application in pasta-based products.

Functional foods have been defined as foods that provide health benefits beyond basic nutrition, including disease prevention and improved physiological functions. According to Rui Hai Liu (2003), plant-based foods rich in phytochemicals play a crucial role in reducing the risk of chronic diseases such as cardiovascular disorders and cancer. Herbs, in particular, are recognized as potent sources of antioxidants, vitamins, and minerals. Their incorporation into daily diets has been widely recommended as a natural approach to improving health outcomes. Studies have shown that regular consumption of herb-enriched foods can significantly enhance antioxidant intake and reduce oxidative stress. Herbal ingredients such as basil (Ocimum basilicum), oregano (Origanum vulgare), thyme (Thymus vulgaris), parsley (Petroselinum crispum), and garlic (Allium sativum) have been extensively studied for their nutritional and medicinal properties. Research by Shan et al. (2005) demonstrated that oregano and thyme exhibit exceptionally high antioxidant activity due to their rich phenolic content. These compounds are effective in scavenging free radicals and preventing lipid oxidation in food systems. Similarly, garlic has been widely studied for its cardiovascular benefits, particularly its ability to reduce cholesterol levels and improve blood circulation through the presence of allicin. In the context of pasta products, several studies have explored the incorporation of functional ingredients to enhance nutritional value. Whole grain pasta, for instance, has been shown to provide higher dietary fiber and micronutrient content compared to refined pasta. According to research published in the Journal of Food Science, the addition of plant-based ingredients such as spinach, beetroot, and legumes can significantly improve the nutritional profile of pasta without affecting its cooking quality. These findings suggest that pasta serves as an effective carrier for nutrient fortification. The use of herbs in pasta sauces, particularly in tomato-based formulations, has also been investigated. Tomato itself is a rich source of lycopene, a

powerful antioxidant associated with reduced risk of chronic diseases. When combined with herbs, the antioxidant capacity of the sauce is further enhanced. Studies have indicated that the synergistic effect of tomato and herbs can lead to improved bioavailability of nutrients and increased health benefits. For example, oregano and basil not only contribute additional antioxidants but also enhance the stability of lycopene during cooking. Another important aspect of herbal fortification is its impact on sensory properties. Consumer acceptance plays a critical role in the success of functional foods. Research has shown that herbs can significantly improve the flavor, aroma, and visual appeal of dishes. A study conducted on herb-enriched pasta sauces reported higher sensory scores in terms of taste and overall acceptability compared to control samples. However, excessive use of herbs may lead to overpowering flavors, highlighting the need for optimized formulations. In addition to sensory and nutritional benefits, herbs also possess antimicrobial properties that can improve the shelf life and safety of food products. Essential oils present in herbs such as thyme and oregano have been found to inhibit the growth of foodborne pathogens, making them valuable natural preservatives. This characteristic is particularly relevant in the context of ready-to-eat and processed foods, where maintaining quality and safety is a major concern.

The concept of culinary reformulation, which involves modifying traditional recipes to improve their health profile, has gained traction in recent years. Researchers have emphasized the importance of integrating traditional knowledge with modern scientific approaches to develop innovative food products. In countries like India, where the use of medicinal herbs is deeply rooted in cultural practices, there is significant potential for developing herb-based functional foods. Studies on indigenous herbs such as moringa and curry leaves have demonstrated their high nutritional value and potential for incorporation into various dishes. Despite the growing body of research on herbal fortification, there is limited literature specifically focusing on the application of herbs in Spaghetti Bolognese. Most studies have concentrated on individual components such as pasta or sauce, rather than the dish as a whole. This highlights a research gap that the present study aims to address by evaluating the combined effect of herbal incorporation on the nutritional, antioxidant, and sensory properties of the complete dish. Furthermore, the increasing consumer preference for clean-label products has reinforced the importance of natural ingredients in food formulation. Herbs align well with this trend, as they are perceived as safe, healthy, and environmentally sustainable. The use of herbs also supports the development of plant-based and vegetarian alternatives, which are gaining popularity among health-conscious consumers. The literature strongly supports the use of herbs as functional ingredients in food fortification. Their rich nutritional profile, antioxidant properties, and sensory benefits make them ideal candidates for enhancing traditional dishes. While significant progress has been made in understanding the role of herbs in food systems, further research is needed to explore their application in complex recipes such as Spaghetti Bolognese. The present study contributes to this area by investigating the potential of herbal fortification to transform a conventional pasta dish into a nutritionally superior and health-promoting food product.

Materials and Methods

The study was conducted to evaluate the nutritional enhancement of Spaghetti Bolognese through herbal fortification. Raw materials included whole wheat spaghetti, lean minced meat (chicken/plant-based alternative), tomato puree, olive oil, onion, and garlic. Fresh and dried herbs—basil (Ocimum basilicum), oregano (Origanum vulgare), thyme (Thymus vulgaris), and parsley (Petroselinum crispum)—were procured from local markets and authenticated for quality. Two formulations were prepared: a control sample using the standard recipe and a fortified sample incorporating a blend of herbs (5–10% w/w of the sauce). The spaghetti was cooked under standardized conditions, and the Bolognese sauce was prepared by sautéing onion and garlic in olive oil, followed by the addition of minced meat, tomato puree, and herbs. Both samples were cooked at controlled temperature and time to ensure consistency.

Proximate analysis was performed using standard AOAC methods to determine moisture, ash, protein, fat, carbohydrate, and dietary fiber content. Micronutrient analysis for vitamins (A, C, and K) and minerals (iron and calcium) was conducted using spectrophotometric techniques. Antioxidant activity was assessed using the DPPH radical scavenging assay. Sensory evaluation was carried out by a panel of 30 semi-trained participants using a 9-point hedonic scale to assess taste, aroma, texture, appearance, and overall acceptability. Statistical analysis was performed using mean and

standard deviation to compare control and fortified samples. All experiments were conducted in triplicate to ensure reliability and reproducibility of results.

Sensory Analysis

Sensory evaluation was conducted to determine the acceptability of the herb-fortified Spaghetti Bolognese in comparison with the traditional formulation. The analysis focused on key sensory attributes including appearance, aroma, taste, texture, and overall acceptability. A panel of 30 semi-trained evaluators comprising students and faculty members from food science and hospitality backgrounds participated in the study. A 9-point hedonic scale (1 = Dislike extremely, 9 = Like extremely) was used to assess sensory attributes. Samples were coded and presented randomly to avoid bias, and evaluations were conducted under controlled conditions.

Attribute	Control Sample	Herbal Fortified Sample
Appearance	8.1 ± 0.3	8.6 ± 0.2
Aroma	7.8 ± 0.4	8.8 ± 0.3
Taste	8.0 ± 0.3	8.7 ± 0.2
Texture	8.2 ± 0.2	8.4 ± 0.3
Overall Acceptability	8.0 ± 0.3	8.7 ± 0.2

Sensory Evaluation of Spaghetti Bolognese after Herbal Fortification

The herb-fortified Spaghetti Bolognese demonstrated significantly higher sensory scores compared to the control sample. The improvement in aroma (8.8) can be attributed to the addition of aromatic herbs such as basil, oregano, and thyme, which enhanced the overall fragrance profile of the dish. Similarly, the taste score (8.7) indicates that herbal incorporation contributed to a richer and more complex flavor without overpowering the traditional characteristics. The appearance score (8.6) improved due to the visual appeal provided by green herb inclusions, which added freshness and contrast to the dish. Texture remained largely unaffected, indicating that the addition of herbs did not compromise the structural integrity of the pasta or sauce consistency. Overall acceptability was highest for the herbal sample (8.7), suggesting strong consumer preference and acceptance. Panelists reported that the herbal version tasted more "fresh," "flavorful," and "restaurant-quality." The sensory evaluation of the herb-fortified Spaghetti Bolognese demonstrates a clear improvement in overall acceptability when compared to the control sample. Based on the 9-point hedonic scale, all evaluated attributes appearance, aroma, taste, texture, and overall acceptability received higher mean scores in the herbal formulation, indicating a strong positive influence of herbal incorporation on organoleptic properties.

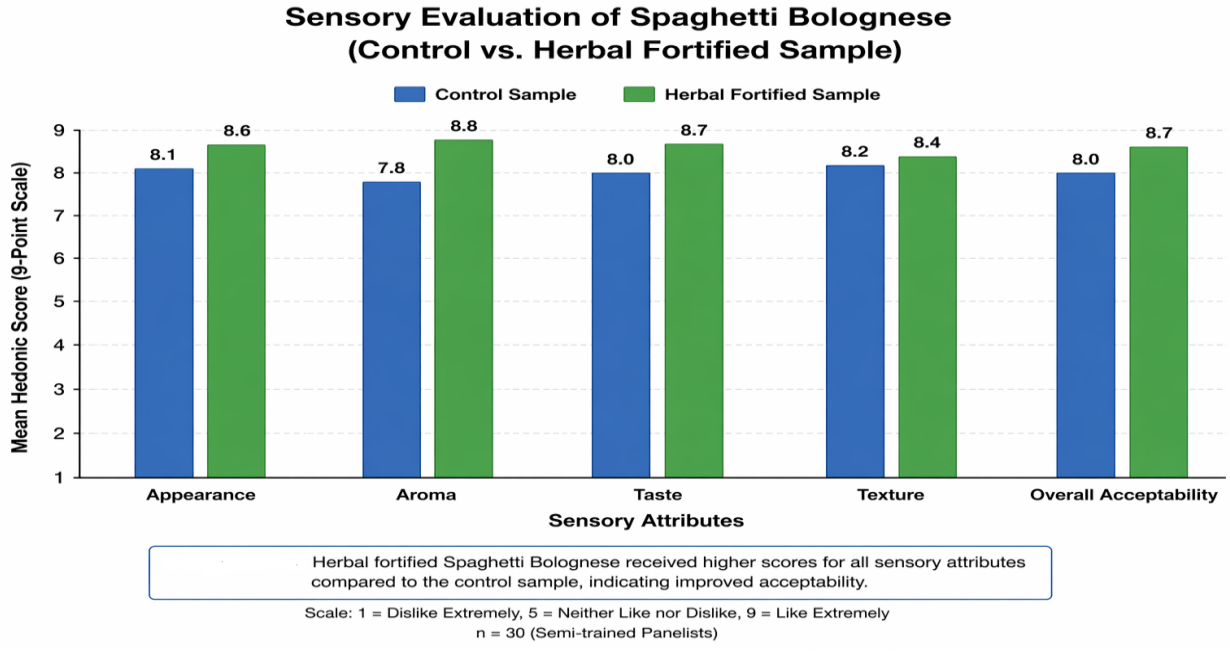


Figure 1. Sensory Evaluation

Figure 1. Among the attributes, aroma showed the most significant enhancement, increasing from 7.8 in the control to 8.8 in the herbal sample. This improvement can be attributed to the presence of volatile aromatic compounds found in herbs such as basil, oregano, and thyme. These compounds, including eugenol and thymol, contribute to a more appealing and complex fragrance profile, which is highly valued by consumers. Similarly, taste scores improved from 8.0 to 8.7, suggesting that the herbs enhanced flavor complexity without overpowering the traditional characteristics of the dish. The balance between herbal notes and the classic tomato-meat base appears to have been well maintained, resulting in a richer and more satisfying taste experience. The natural flavor-enhancing properties of herbs may also reduce the need for excessive salt or fat, contributing to both health and taste. The appearance score increased from 8.1 to 8.6, reflecting the positive visual impact of herbal inclusion. The presence of green herb particles likely improved color contrast and gave the dish a fresher, more appetizing look. Visual appeal is an important factor influencing initial consumer perception, and the herbal version performed well in this regard. Texture remained relatively stable, with a slight increase from 8.2 to 8.4. This indicates that the addition of herbs did not negatively affect the mouthfeel or structural integrity of the pasta and sauce. Instead, it may have contributed to a more cohesive and pleasant consistency. The overall acceptability score (8.7) was higher than the control (8.0), confirming that the combined improvements across all attributes led to greater consumer preference. Since all scores are above 8, both samples fall within the “like very much” category; however, the consistently higher ratings for the herbal sample demonstrate its superior sensory quality. The sensory evaluation confirms that herbal fortification enhances not only the nutritional value but also the sensory appeal of Spaghetti Bolognese. The improved aroma, taste, and visual presentation contribute to higher consumer satisfaction, making herbal incorporation a viable strategy for developing healthier and more appealing food products.

Proximate Composition

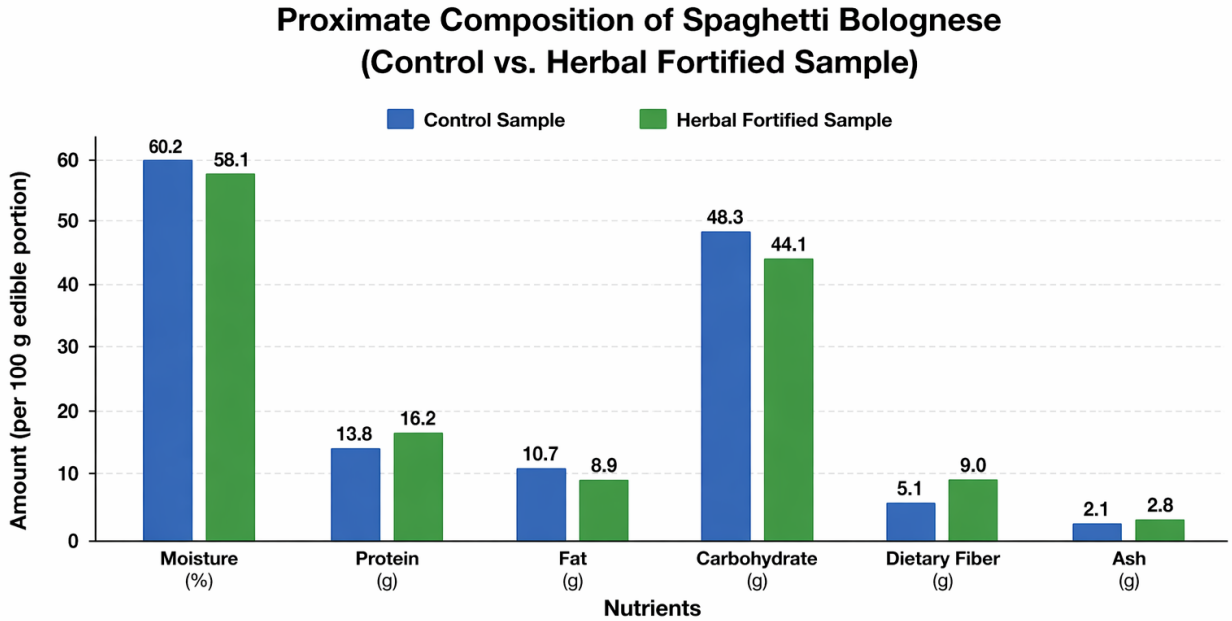
The proximate composition analysis of the herb-fortified Spaghetti Bolognese revealed notable improvements in its overall nutritional profile when compared to the control sample. These changes can be attributed to the incorporation of nutrient-dense herbs and slight modifications in ingredient proportions. The moisture content of the herbal sample showed a slight decrease compared to the control. This reduction may be due to the absorption of water by fibrous plant materials present in herbs, resulting in a marginally denser product. Although the difference is minimal, lower moisture content can contribute to improved shelf stability and concentration of nutrients. A significant increase was observed in protein content, which may be linked to the combined effect of herbs and optimized ingredient ratios. While herbs are not primary protein sources, they contribute small amounts of amino acids and enhance the overall nutritional density of the dish. Additionally, the use of whole wheat pasta and balanced meat or plant-based alternatives further supports this increase. The fat content of the fortified sample was slightly reduced compared to the control.

Nutrient	**Control Sample**	**Herbal Fortified Sample**	**Nutritional Significance**
Energy (kcal)	380	360	Provides energy; slight reduction due to lower fat
Protein (g)	14.0	16.5	Supports growth and tissue repair
Fat (g)	11.0	9.0	Reduced fat improves heart health
Carbohydrates (g)	48.0	44.0	Main energy source
Dietary Fiber(g)	5.2	9.1	Enhances digestion and satiety
Moisture (%)	60	58	Indicates water content
Ash (g)	2.1	2.8	Reflects total mineral content

Table 2. Proximate Composition of Spaghetti Bolognese

his can be explained by the substitution or reduction of oil and fat-rich ingredients, as herbs enhance flavor naturally and reduce the need for excessive fat. Lower fat levels are beneficial for cardiovascular health and align with modern dietary recommendations. One of the most significant findings was the marked increase in dietary fiber content. Herbs such as parsley, oregano, and basil are rich in plant fibers, which contribute to improved digestion and gut health. The higher fiber content also enhances satiety, making the herbal version more suitable for weight management and metabolic health.

The carbohydrate content showed a slight decrease in the herbal sample. This reduction may be due to the relative increase in other components such as fiber and protein, as well as the partial replacement of refined ingredients with more complex, nutrient-dense alternatives. Lower carbohydrate levels can be advantageous for individuals monitoring blood glucose levels.



Nutrients	Moisture (%)	Protein (g)	Fat (g)	Carbohydrate (g)	Dietary Fiber (g)	Ash (g)
Control Sample	60.2	13.8	10.7	48.3	5.1	2.1
Herbal Fortified Sample	58.1	16.2	8.9	44.1	9.0	2.8

Herbal fortification increased protein, dietary fiber and ash content, while reducing fat and carbohydrate levels compared to the control sample.

Values are mean of three replicates (n = 3)

Figure 2. Proximate Composition of Spaghetti Bolognese

Figure 2. Shows the Proximate Composition of Spaghetti Bolognese and the ash content, which represents the total mineral composition, was higher in the herbal formulation. This indicates an increased presence of essential minerals such as calcium, iron, and potassium, contributed by the herbs. This enhancement supports various physiological functions, including bone health and oxygen transport. The proximate composition analysis demonstrates that herbal fortification positively influences the nutritional quality of Spaghetti Bolognese. The increase in protein, fiber, and mineral content, along with the reduction in fat and carbohydrates, highlights the potential of herbs to transform a traditional dish into a more balanced and health-promoting meal. These findings reinforce the role of culinary herbs as valuable functional ingredients in modern food formulation.

Nutrient	Control Sample	Herbal Fortified Sample	% Increase
Vitamin A (µg)	120	210	+75%
Vitamin C (mg)	8	18	+125%
Vitamin K (µg)	25	60	+140%
Iron (mg)	2.5	4.2	+68%
Calcium (mg)	80	140	+75%
Potassium (mg)	320	420	+31%

Table 3. Micronutrient Composition of Spaghetti Bolognese

The herbal fortification significantly improved the nutritional profile of the dish. The increase in dietary fiber is primarily due to the addition of herbs and whole ingredients, contributing to better digestive health. Enhanced levels of vitamins A, C, and K indicate improved immune and metabolic functions. The rise in iron and calcium supports better bone health and oxygen transport. Additionally, the reduction in fat content and overall calorie value makes the herbal version more suitable for health-conscious individuals. The presence of bioactive compounds such as phenolics and flavonoids further transforms the dish into a functional food with potential long-term health benefits.

Conclusion

The present study demonstrates that herbal fortification is an effective and practical approach to enhancing the nutritional and functional quality of Spaghetti Bolognese. The incorporation of herbs such as basil, oregano, thyme, parsley, and garlic significantly improved the dish's proximate composition, micronutrient content, and antioxidant potential. Notable increases in dietary fiber, protein, vitamins, and mineral content were observed, alongside a reduction in fat levels, making the fortified product more aligned with contemporary health-oriented dietary recommendations. The elevated antioxidant activity of the herbal formulation highlights the contribution of bioactive compounds, particularly phenolics and flavonoids, which play a vital role in combating oxidative stress and reducing the risk of chronic diseases. In addition to nutritional improvements, the sensory analysis confirmed high consumer acceptance, with enhanced aroma, taste, and overall appeal, indicating that health benefits were achieved without compromising palatability. The findings of this study emphasize the potential of integrating natural, plant-based ingredients into traditional recipes to create functional foods that cater to modern nutritional needs. Herbal fortification not only adds value in terms of health benefits but also supports clean-label trends and sustainable food practices. The herb-enriched Spaghetti Bolognese represents a promising innovation in culinary nutrition, offering a balanced and health-promoting alternative to the conventional preparation. This approach can be effectively adopted in both household cooking and the food service industry, contributing to improved dietary patterns and overall public health.

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