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Innovative Vegetable Chips: Harnessing the Nutritional Power of Underutilized Leafy Greens

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ABSTRACT: This study investigates the acceptability of spinach-cabbage chips in three flavor variants: plain, cheese, and barbeque, specifically targeting preschoolers as the primary evaluators. A sensory evaluation was conducted, assessing the chips based on appearance, color, texture, taste, aroma, and overall acceptability. Data were analyzed using One-Way Analysis of Variance (ANOVA) to identify the most preferred nutri-chip formulation, while Kramer's Rank-Sum Test determined the favored variant among the participants. The study utilized fresh spinach and cabbage, focusing on their nutritional profiles and the production process for the chips. Key methodologies included sensory evaluations, cost analysis of ingredients, and calculations of theoretical vitamin A content, along with the percentage of the Recommended Nutrient Intake (RENI) for vitamin A per 50-gram serving for children aged 4-10 years. Results indicated that the optimal formulation comprised 200 grams of spinach and 100 grams of cabbage, with no significant differences at the 5% level in appearance and color between formulations. However, significant differences were noted in texture, taste, aroma, and overall acceptability. The spinach-cabbage nutri-chips contained 512 µg of Retinol Equivalents (RE) of vitamin A, translating to 12.8% of the daily recommended intake for preschoolers. The findings suggest that spinach-cabbage nutri-chips can serve as a nutritious snack option to enhance vitamin A intake among preschoolers and may be beneficial for supplementary feeding programs. Recommendations for production, packaging, and further research into the product's shelf life and applicability in school feeding initiatives are provided.

KEYWORDS: Vegetable Chips, Nutritional Value, Underutilized Leafy Green, Spinach-Cabbage Formulations, Sensory Evaluation

I. INTRODUCTION

Micronutrients, which include essential vitamins and minerals, are vital for maintaining good health. Among these, Vitamin A plays a crucial role as a fat-soluble vitamin, encompassing both natural forms and synthetic analogs known as retinoids. It can be sourced from both animal products, such as butter, egg yolks, and liver, and plant-based sources, where it exists as provitamin A carotenoids like beta-carotene, alpha-carotene, and betacryptoxanthin (Institute of Medicine, 2001; Ross, 2010).

Vitamin A exists in three primary forms: retinols (preformed vitamin A), beta-carotenes (plant-based), and carotenoids. Retinol is the most active form and is predominantly found in animal sources, while beta-carotene is converted into retinol in the body (Olson, 1996). This vitamin is essential for various physiological functions, including vision, immune response, reproductive health, and gene regulation (Institute of Medicine, 2001; Ross, 2010; Blomhoff, 1994). Deficiencies in Vitamin A can lead to serious health issues, particularly in developing countries, where the signs include impaired vision, dry skin, and increased susceptibility to infections (Sommer, 1995).

In the Philippines, Vitamin A deficiency is a pressing public health issue, significantly impacting children. In 1998, nearly 38% of children aged 0-5 years exhibited low plasma retinol levels (Food and Nutrition Research Institute, 2001). The economic challenges faced by the country have likely exacerbated this deficiency, contributing to a broader malnutrition crisis. The link between economic conditions and nutritional status is evident, as declines in the economy correlate with increased rates of underweight and wasting among children (Solon et al., 2000; Florentino & Tanchoco, 1988).

The consequences of Vitamin A deficiency extend beyond health, leading to increased morbidity and mortality rates among children and poor pregnancy outcomes (Sommer & West, 1996). While the government has initiated high-dose supplementation programs for young children, more comprehensive strategies may be needed to effectively combat this issue (Solon et al., 2000). Additionally, the Philippines faces challenges related to vegetable waste management, particularly in La Trinidad, Benguet, where

significant amounts of vegetable waste could be repurposed into nutrient-rich compost, potentially improving agricultural productivity and nutrition outcomes (JDP/SCA-PIA CAR, Benguet, 2007).

II. RELATED LITERATURES

Spinach, scientifically known as Spinacia oleracea, is an edible flowering plant from the Amaranthaceae family, native to central and southwestern Asia (Douglas, 2010; Morelock & Correll, 2008). It is typically an annual plant that can grow up to 30 cm in height and may survive winter in temperate climates. The leaves are alternate and vary significantly in size, while the flowers are inconspicuous and develop into small fruit clusters containing seeds (Douglas, 2010; Morelock & Correll, 2008).

Cabbage, or Brassica oleracea var. capitata Linn., is a vital vegetable crop in the Philippines, significantly contributing to both the economy and the nutrition of its people (Knott & Deanon, 2009; Barba, 2006). It ranks first in production among leafy vegetables and is essential for a balanced diet due to its high content of vitamins A, B, and C, as well as minerals like calcium (Knott & Deanon, 2009; Barba, 2006). Cabbage thrives in fertile, welldrained soils, particularly at altitudes between 700 and 2,000 feet, and is best cultivated during cooler months (Knott & Deanon, 2009; Barba, 2006). However, it is highly perishable and susceptible to rotting, which can lead to market gluts and price fluctuations, adversely affecting farmers (Hurrell, 2006; Barba, 2006).Nutritionally, spinach is rich in antioxidants, vitamins, and minerals, especially when consumed fresh or lightly cooked (Ball, 2006; Bergquist et al., 2006). It is a significant source of vitamin A, C, E, K, and iron, although the presence of high oxalate levels can inhibit iron absorption (Ball, 2006; Bergquist et al., 2006). Cabbage is recognized as an excellent source of vitamin C and a good source of vitamin A, with notable antioxidant properties attributed to its polyphenols (World's Healthiest Foods, 2023; Barba, 2006).

Spinach can be categorized into three main types: savoy, flat/smooth leaf, and semi-savoy. Savoy spinach features dark green, crinkly leaves and is commonly sold fresh, while flat/smooth leaf spinach has broader leaves that are easier to clean, often used for canned and processed foods (Wright, 2010; Morelock & Correll, 2008). Semi-savoy spinach is a hybrid variety that combines characteristics of both types, suitable for both fresh markets and processing (Wright, 2010; Morelock & Correll, 2008).The health benefits of spinach are largely attributed to its antioxidant content, which provides anti-inflammatory effects and reduces the risk of health issues related to oxidative stress (Blumberg, 2004; Podsędek, 2007). Spinach consumption has been linked to decreased risks of atherosclerosis and high blood pressure, potentially due to its unique peptides that help regulate blood pressure (Basu et al., 2014). Additionally, spinach ranks highly in nutrient richness, being rich in vitamins and phytonutrients (World's Healthiest Foods, 2023). Cabbage also boasts impressive antioxidant properties, particularly due to its polyphenols, which contribute to its cancer prevention benefits (World's Healthiest Foods, 2023; Barba, 2006).

Cabbage is noteworthy as a probiotic superfood, particularly when fermented into products like sauerkraut, which enhances its nutritional profile and provides beneficial bacteria (Barba, 2006; Pardo & Zufía, 2012). This fermentation process not only preserves the cabbage but also increases its vitamin B content, making it a valuable food source, especially for those following a vegan diet (Barba, 2006).Moreover, spinach is considered excellent brain food due to its flavonoids, which may help protect against cognitive decline and improve learning and motor skills in aging populations (Gómez-Pinilla, 2008; Shukitt-Hale, 2015). Studies suggest that diets rich in spinach and other green leafy vegetables can significantly reduce neurodegenerative changes (Shukitt-Hale, 2015).To enhance the consumption of spinach, particularly among children who may be deterred by its bitter taste, various methods have been explored. One effective approach involves adding calcium, which neutralizes the bitterness by reacting with oxalic acid in spinach (Liang et al., 2005). Mixing spinach with milk creates a "spinach milk juice" that is devoid of bitterness while enhancing nutritional value (Liang et al., 2005). Additionally, incorporating oil, particularly olive oil, into spinach dishes can mask bitterness and improve flavor (Liang et al., 2005). Cooking methods such as boiling or steaming can also reduce bitterness, though they may lead to some nutrient loss (Robert & Praulx, 2006).

The Garantisadong Pambata program in the Philippines aims to improve child health through routine health services, including vitamin A and iron supplementation, highlighting the importance of micronutrients for growth and development (DOH, 2022). Vitamin A plays a crucial role in vision, immune function, and cellular differentiation, and its deficiency remains a significant public health issue globally (WHO, 2009).

III. METHODOLOGY

The research study employed an experimental design to evaluate the most acceptable variant of spinachcabbage nutritional chips based on sensory attributes such as appearance, color, texture, taste, aroma, and overall acceptability. This evaluation was conducted using the Facial Hedonic Scale, as depicted in Figure 2. The sample formulations included different ratios of dried spinach and cabbage, specifically 100 grams of dried spinach with 100 grams of dried cabbage and 200 grams of dried spinach with 100 grams of dried cabbage.

Participants in the study consisted of thirty preschoolers aged 4 to 10 years from City Camp Barangay in Baguio City, who conducted the facial sensory evaluation to identify the most acceptable nutritional chip variant. Data gathering involved cooking the nutritional chip formulation of 200 grams of spinach and 100 grams of cabbage, followed by sensory evaluation using the Facial Hedonic Scale. This scale provided descriptive rankings from "Gustong-gusto (Like Very Much)" to "Hindi talagang gusto (Dislike Very Much)

For statistical analysis, the One-Way Analysis of Variance (ANOVA) was utilized to assess the sensory evaluation results, while Kramer's Rank-Sum Test was employed to determine the preferred variant among the preschoolers. This methodology ensures a comprehensive understanding of the sensory preferences for the nutritional chips and supports the validity of the findings.

IV. RESULT AND DISCUSSION

The study aimed to determine the most acceptable spinach-cabbage nutritional chips among three variants: plain, cheese, and barbecue flavors, focusing on preschoolers from City Camp Barangay in Baguio City. The findings revealed that the formulation containing 200 grams of spinach and 100 grams of cabbage was the most acceptable. There were no significant differences at the 5% level in terms of appearance and color; however, highly significant differences were noted for texture, taste, aroma, and general acceptability between the two formulations. The vitamin A content of the chips was equivalent to 512 µg RE, translating to 51.2 µg RE per 50gram pack. This amount provides a total of 128 µg RE of vitamin A per serving, which is beneficial since the recommended daily intake for preschoolers aged 4-10 years is 400 µg RE. Therefore, these chips can serve as a nutritious snack to supplement preschoolers' vitamin A intake and can be included in supplementary feeding programs.

The study also developed three variants using the 200 grams of spinach and 100 grams of cabbage formulation: plain, cheese, and barbecue. The cheese-flavored chips were ranked as the most preferred by preschoolers, followed by barbecue-flavored chips, while plain chips were the least preferred. Conclusions drawn from the study indicated that preschoolers had different perceptions when rating the chips based on appearance, color, taste, aroma, and general acceptability, although they shared a common rating for texture. In terms of overall acceptability, cheese-flavored chips emerged as the most preferred, while plain chips were the least acceptable.Based on these findings, several recommendations were made for producing spinach-cabbage nutrichips. It is advised to use a deep fryer to prevent burnt chips from sticking together during frying. Proper packaging techniques should be employed to ensure the chips are well-strained and free from contamination. Moreover, maintaining a clean working environment and adhering to sanitation practices is crucial. The researcher also recommends conducting a study on the shelf life of the spinach-cabbage nutritional chips and suggests that these chips be introduced to Home Economics teachers for use in school feeding programs for grades 1-5, as they can help meet at least one-third of preschoolers' vitamin A requirements.

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