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Research Article

DIABETIC, KETOGENIC, AND FIBER-ENRICHED MOUSSE DEVELOPED USING STEVIA AND ARTICHOKE POWDER: SENSORY EVALUATION AND CONSUMER PREFERENCES

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Abstract

In this study, a functional mousse suitable for diabetic and ketogenic diets was developed using stevia and artichoke powder as a source of prebiotic fiber, and its sensory acceptability was evaluated. Three different formulations were prepared for this purpose: a classic sucrose-based classic/control (C), a stevia-sweetened version (S), and a version with both stevia and artichoke powder (SA). Sensory analyses were performed by 15 panelists, incorporating a triangle test and a hedonic panel with a 5-point Likert scale. The results of the triangle test showed that the stevia-sweetened mousse was statistically distinguishable from the control group ($p<0.05$). Although no significant difference was detected among the groups in the hedonic evaluation ($p>0.05$), the S group received the highest liking score (4.27±0.87), followed by the SA group (4.11±1.08). Furthermore, the cost analysis revealed that the SA formulation was 67% more expensive than the control group. In conclusion, it was determined that sensorially acceptable products can be developed with these functional ingredients; however, texture optimization and cost-effectiveness are of critical importance for commercial success.

Keywords: Stevia, Prebiotic, Consumer Preference

Introduction

The contemporary rise in consumer health consciousness has significantly driven the demand for functional foods, particularly those with no added sugar. This trend is further reinforced by the emergence of chronic metabolic disorders as a global health concern. Nutritional strategies play a central role, especially for individuals managing conditions where blood sugar control is critical, such as diabetes, or for those adopting specialized dietary models like the ketogenic diet (WHO, 2020). According to data from the International Diabetes Federation (IDF, 2021), the number of individuals with diabetes worldwide reached 537 million by the end of 2021, with Turkey ranking among the countries with the highest diabetes prevalence in Europe (Turkish Diabetes Foundation, 2019). This landscape underscores the importance of developing innovative food products that cater to specific health needs and promote overall well-being.

In this context, the adverse effects of high-sugar foods on obesity and metabolic syndrome have heightened interest in natural, zero-calorie sweeteners. Steviol glycosides, derived from the Stevia plant, offer a widely used alternative in the food industry due to their sweetness, which is 100-300 times greater than sucrose, as well as their thermal and pH stability. The neutral effect of steviol glycosides on blood sugar makes them an ideal component for diabetes management and low-carbohydrate diets. Furthermore, the literature includes studies on their potential biological activities, such as antioxidant and anti-inflammatory properties (Chatsudthipong and Muanprasat, 2009; Manisha, Soumya and Indrani, 2012; Shukla et al., 2009).

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In recent years, the ketogenic diet, based on restricted carbohydrate intake and high fat consumption, has gained prominence among dietary approaches for improving metabolic health. Clinical studies have demonstrated its potential to improve glycemic control, enhance insulin sensitivity, and support weight loss (Hallberg et al., 2018; Kelly, Unwin and Finucane, 2020). Another crucial component in nutritional strategies is prebiotic fibers. Artichoke (*Cynara scolymus L.*), in particular, is a rich source of prebiotic fibers such as inulin and fructo-oligosaccharides. These components positively modulate the gut microbiota, thereby increasing the production of short-chain fatty acids (SCFAs). In addition to supporting gut health, SCFAs can also exert indirect positive effects on overall metabolic health (Jalili et al., 2020; Nazni et al., 2006). Moreover, incorporating plant-based sources like artichoke in powdered form into foods holds significant potential for the valorization of food industry by-products and for sustainable food production.

This study aims to develop an innovative, fiber-enriched mousse recipe using stevia and artichoke powder, compliant with the principles of diabetic and ketogenic diets, and to determine how the product is evaluated by individuals in terms of its sensory characteristics and consumer preferences. The research explores the potential for developing a product aimed at both individuals with specific dietary requirements and the general consumer seeking healthier dessert alternatives.

Conceptual Framework

Diabetes: Definition, Epidemiology, and Treatment Approaches

Definition and Epidemiology: Diabetes is a disease characterized by the inability to maintain blood glucose levels within the normal range due to insufficient insulin production by the pancreas or ineffective utilization of insulin in the body. Both type 1 diabetes (an autoimmune form typically observed in childhood) and type 2 diabetes (associated with insulin resistance) develop as a result of interactions among genetic, environmental, and lifestyle factors. The global rise in diabetes prevalence is particularly linked to risk factors such as poor-quality nutrition, obesity, and a sedentary lifestyle. Studies conducted in Turkey indicate significant increases in diabetes prevalence not only across different regions but also among various age groups (IDF, 2019; Turkish Diabetes Foundation, 2019).

Treatment Approaches: In the management of diabetes, medical interventions—including the use of insulin and oral antidiabetic medications—are complemented by medical nutrition therapy (MNT) and regular exercise programs. Achieving successful outcomes in diabetes management requires personalized interventions that consider individual dietary habits, lifestyle, and metabolic goals (Eroğlu, 2017; TEMD, 2019).

Stevia: Origin, Components, and Health Effects

Origin and Components: *Stevia rebaudiana*, a plant native to South America and belonging to the chrysanthemum family, is renowned for its steviol glycosides extracted from its leaves, which are used as natural sweeteners. These glycosides are favoured in the food industry due to their sweetness—significantly exceeding that of sucrose—as well as their heat and pH stability and high fibre content (Cariño-Cortés et al., 2007; Dinçel, Alçay and Badayman, 2018).

Health Assessment: Steviol glycosides, the primary bioactive compounds in stevia, are recognized for a range of health benefits. These compounds have been shown to support metabolic regulation by modulating key hormonal pathways, including enhancing insulin secretion and sensitivity, while concurrently suppressing glucagon release. Furthermore, some evidence highlights their broader systemic benefits, including significant anti-inflammatory, anti-tumour, and anti-hyperglycaemic properties (Anton et al., 2010; Chatsudthipong and Muanprasat, 2009; Jeppesen et al., 2000; Nuñez, 2011).

Ketogenic Diet: Definition, Implementation Principles, and Metabolic Effects

Definition and Principles: The ketogenic diet is a nutritional model in which the majority of daily caloric intake is derived from fats, protein consumption is maintained at a moderate level, and carbohydrate intake is significantly restricted. Initially employed in the treatment of epilepsy, this diet has demonstrated effective outcomes in addressing metabolic disorders such as obesity, polycystic ovary syndrome (PCOS), and diabetes. In various versions of the ketogenic diet, daily carbohydrate intake is limited to 20–50 grams, although some protocols may adopt less stringent restrictions (Volek et al., 2002; Wheless, 2008).

Effects on Metabolic Health: Clinical studies have reported that the ketogenic diet can lead to a decrease in HbA1c levels, an increase in insulin sensitivity, and a reduction in body weight. It is also noted that reducing

carbohydrate intake may offer additional benefits such as reducing feelings of hunger and prolonging satiety (Hallberg et al., 2018; Kelly, Unwin and Finucane, 2020; Yancy et al., 2005).

Prebiotics and Artichokes: Health and Sustainability

The Concept of Prebiotics: Prebiotics are nutritional components that are not digested by human enzymes but are selectively fermented by the gut microbiota, thereby conferring health benefits to the host. These components, particularly through the increased production of short-chain fatty acids (SCFAs), help maintain gut flora balance, reduce gastrointestinal permeability, and lower inflammation levels (Gibson and Roberfroid, 1995; Schley and Field, 2002).

Artichoke, Health, and Sustainability: Artichoke (*Cynara scolymus L.*), a vegetable native to the Mediterranean climate, contains various bioactive compounds, primarily polyphenols. The edible part of the artichoke is rich in prebiotic components such as inulin and fructooligosaccharides. These components may contribute to overall gut health by supporting the gut microbiota and increasing SCFAs production, thereby improving glycemic control through enhanced insulin sensitivity (Jalili et al., 2020; Nazni et al., 2006). Additionally, the use of by-products such as leaves, which are produced during artichoke processing, in powder form contributes to sustainable food production by reducing food waste and supporting the circular economy.

Method

Materials of the Study

The raw materials and components used in this study were obtained from the following sources:

Eggs: Pasteurized eggs were supplied by Anako. Anako, an egg processing factory in Konya, Türkiye.

Other Basic Ingredients: Bitter chocolate, cream, granulated sugar (sucrose), and stevia samples were purchased from a local market.

Artichoke Powder: In this study, artichoke powder, which was produced through the extraction and lyophilization of artichoke leaves as part of a previous master's thesis, was used in the preparation of the mousses to increase their fiber content. The artichoke powder utilized contained 47.8±0.5 g of inulin per 100 grams (Karaduman, 2024).

Development of Mousse Formulations

In this study, three different mousse formulations were developed: one control and two alternatives. The reference recipe for the classic (control) group (C) was adapted from Mastering the Art and Craft - Baking & Pastry (The Culinary Institute of America, 2015). The alternative formulations consisted of a group in which sugar was substituted with stevia (S group) and a group that included the addition of artichoke powder along with stevia (SA group). The ingredients and their quantities used in the formulations are presented in Table 1. The yield from each recipe is approximately 4 servings of mousse.

Table 1. Composition of Mousse Formulations

Ingredients	Classic (Control)(C)	Stevia (S)	Stevia + Artichoke Powder (SA)
Dark Chocolate (70% cocoa)	300 mL	300 mL	300 mL
Cream (35% fat)	142 g	142 g	142 g
Egg Yolk	28 g	28 g	28 g
Egg White	56 g	56 g	56 g
Granulated Sugar	28 g	-	-
Stevia	-	14 g	14 g
Artichoke Powder	-	-	6.75 g

Mousse Production Method

All mousse formulations were produced following a standard procedure:

- Cream (35% fat) was whipped using a mixer until soft peaks formed and was subsequently stored at +4°C until analysis.
- Dark couverture chocolate (70% cocoa) was melted using a bain-marie (double boiler) method and brought to a temperature of 49°C.

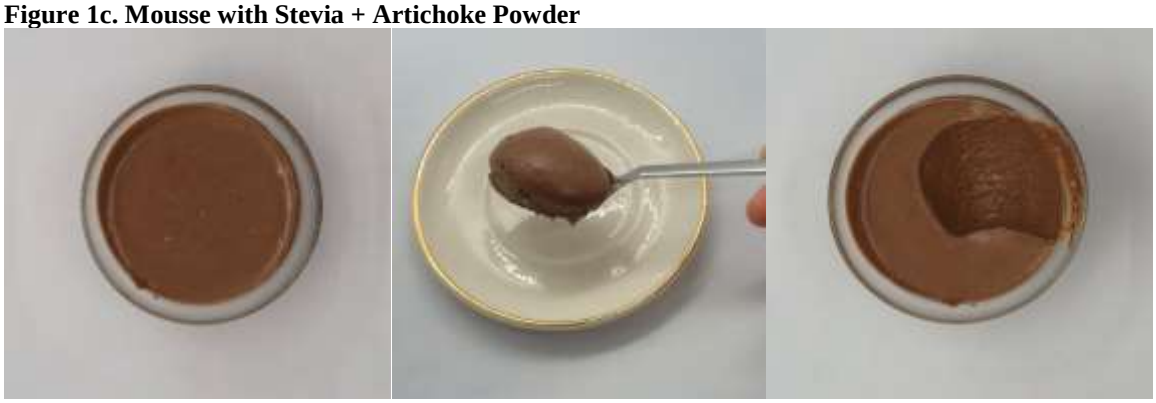
- In a separate bowl, pasteurized egg whites and yolks were whisked together with either granulated sugar (C group), stevia (S group), or stevia and artichoke powder (SA group), according to the respective formulation.
- The resulting egg base was whisked with the melted chocolate at high speed to obtain a homogeneous mixture.
- In the final stage, the refrigerated whipped cream was gently incorporated into the chocolate mixture using a spatula with a folding technique.
- The final product was transferred into individual serving containers, covered, and refrigerated at +4°C until its structure was completely stabilized.

Sample images of the produced mousses are presented below (Figure 1a, Figure 1b, Figure 1c):

Figure 1a. Classic (Control) Mousse

Figure 1b. Mousse with Stevia

Figure 1c. Mousse with Stevia + Artichoke Powder



Sensory Evaluation Application

The sensory evaluation was conducted by a panel comprising academic and administrative staff from the Faculty of Tourism and Faculty of Health Sciences at İzmir Katip Çelebi University. It took place on February 6–7, 2024, in the practical kitchen of the Department of Gastronomy and Culinary Arts. The evaluation process was carried out in two phases:

Triangle Test: The triangle test was conducted to determine whether a perceivable sensory difference existed between the classic mousse (control) and the mousse prepared with stevia. The test was performed with a panel

of 15 participants. In each trial, panelists were presented with three samples coded with three-digit random numbers. One of these samples was the sucrose-based control, while the other two were from the stevia-sweetened formulation. Panelists were instructed to taste the samples and identify which one was different from the others.

Hedonic Panel: One day following the triangle test, a sensory acceptance evaluation was conducted on the three mousse formulations: the classic (control), the stevia-sweetened, and the stevia with artichoke powder. All samples were prepared in duplicate for the assessment. Panelists were provided with water to cleanse their palates between tasting each sample. The sensory acceptance was measured using a 5-point Likert scale, with points corresponding to: 5 ("I liked it very much"), 4 ("I liked it"), 3 ("Neither liked nor disliked"), 2 ("I disliked it"), and 1 ("I did not like it at all").

Ethical Considerations

Ethical approval for the study was obtained from the Izmir Katip Çelebi University Social Research Ethics Committee (Decision No. 2023/19-02).

Statistical Evaluation

The data obtained from the sensory evaluations were analysed in two stages:

Triangle Test Analysis: The triangle test results were interpreted according to the correct response frequency table (TS5915, 1988). The statistical significance of sensory differences between the products was evaluated based on the percentage of correct identifications by the panellists.

Consumer Acceptance Test: The acceptance scores provided by the panellists were compared using one-way ANOVA in SPSS. A significance level of $p < 0.05$ was established, and results with p values below this threshold were considered statistically significant.

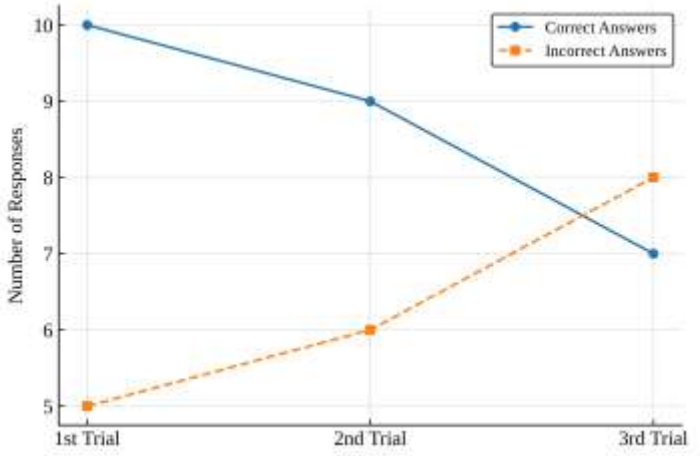
Cost Analysis

A basic cost analysis was conducted to evaluate the industrial applicability and economic feasibility of the developed functional mousse formulations. This analysis calculated the raw material cost per portion for each of the three different formulations: classic (control) (C), stevia-sweetened (S), and stevia with artichoke powder (SA). The costs were determined based on the ingredient quantities specified in the recipes (Table 1) and the average market prices of these components at the time the study was conducted. The objective of this calculation was to comparatively illustrate the impact that the substitution and addition of functional ingredients—namely stevia and artichoke powder—had on the final product cost.

Result and Discussion

This study aimed to evaluate the sensory acceptability and consumer preferences of a mousse formulation enriched with steviol glycosides and artichoke powder, tailored for diabetic and ketogenic diets. The findings provide valuable insights into both the impact of the functional components on the product characteristics and consumer expectations in the development of new products.

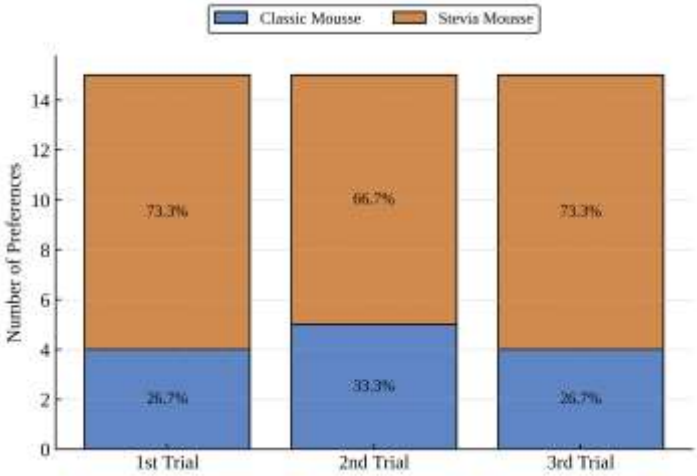
Figure 2. Comparison of Triangle Test Results



The results from the triangle test demonstrated that panellists were able to perceive a statistically significant difference between the classic mousse and the stevia-based mousse (Figure 2). The test was conducted in three replicates with 15 panelists, resulting in a total of 45 responses. Among these, 26 correct identifications were made, which is statistically significant ($p<0.05$) and exceeds the critical threshold for demonstrating a perceptible difference (TS5915, 1988). This finding indicates that the taste profile of the mousse containing steviol glycosides is markedly different from that of the traditional sucrose-based formulation, a result consistent with previous studies reporting that products can be differentiated due to the distinct taste imparted by stevia compared to sucrose (Faisal and Mukhriza, 2019; Koç, 2018).

During the three repeated trials, the consumption preferences of the panellists were also evaluated. It was observed that the mousse containing stevia was preferred at higher rates compared to the classic mousse in all trials (Figure 3). This finding suggests that despite the perceptible taste difference, the stevia-enhanced mousse was perceived as more appealing in its sensory attributes, thereby offering a significant advantage in acceptability over the classic formulation.

Figure 3. Consumer Preferences for Products in the Triangle Test



When reviewing the hedonic test results, it is notable that the mousse with added stevia (4.27 ± 0.87) received a higher average score compared to the classic mousse (3.90 ± 0.85) and the mousse with the stevia + artichoke powder combination (4.11 ± 1.08), although no statistically significant differences were found among the groups ($p > 0.05$) (Figures 4 and Table 2). This observation may be attributed not only to individual variations in taste preferences among panellists but also to textural changes induced by the addition of artichoke powder. The high fibre content of the artichoke powder, particularly inulin, likely imparted a slightly granular texture to the product, potentially affecting the ratings of some panellists. Indeed, Morais et al. (2015) observed similar textural changes in chocolate milk enriched with prebiotic fibre and emphasized the importance of formulation optimization. Nonetheless, the fact that the stevia + artichoke powder combination achieved a higher average score than the classic mousse suggests that the functional components were positively perceived by consumers as a "healthy alternative." This hypothesis is further supported by findings from Faisal and Mukhriza (2019), which indicated that 50% of stevia-sweetened yogurts were rated as "quite liked."

Figure 4. Mean Liking Scores by Mousse Formulations

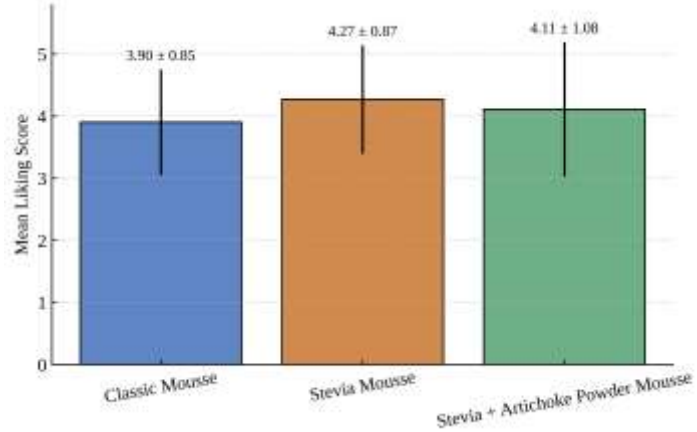


Table 2. One-Way ANOVA Results for Liking Scores of Mousse Formulations

	Source of Variation	SS	df	MS	F	p-value
Stevia	Between groups	0.171	3	0.057	0.068	0.976
	Within groups	21.695	26	0.834		
	Total	21.867	29	—		
Stevia + Artichoke Powder	Between groups	0.633	3	0.211	0.165	0.919
	Within groups	33.233	26	1.278		
	Total	33.867	29	—		

SS = Sum of squares; df = Degrees of freedom; MS = Mean square.

These findings offer significant implications for the development of functional foods targeting specific metabolic health goals, such as glycemic control, ketogenic lifestyles, and weight management. The developed formulation is compatible with the principles of a ketogenic diet, offering a suitable dessert alternative for individuals following this dietary model, which has been reported to improve HbA1c levels (Hallberg et al., 2018). Simultaneously, the formulation supports glycemic control strategies. The potential of steviol glycosides to stimulate insulin secretion (Jeppesen et al., 2000), combined with the capacity of prebiotic inulin fiber from artichoke powder to enhance satiety and slow postprandial glucose absorption (Jalili et al., 2020), strengthens the product's potential to both satisfy sweet cravings in diabetic diets and prevent excessive calorie intake. The preference for the stevia-containing formulations over the classic recipe in our study is significant, as it demonstrates that these health benefits can be delivered in a product that is also sensorially acceptable.

From the perspective of food technology and formulation science, the combination of stevia and artichoke powder presents both opportunities and challenges. The synergistic use of these two components can enhance the product's functionality. For example, it has been reported in the literature that inulin reduces the precipitation issue of stevia in dairy products (Rad et al., 2012) and enhances probiotic viability (Abdolmaleki Shahsavani and Mostaghim, 2023). This synergistic effect may partially explain why, in our study, the SA formulation achieved a higher mean liking score than the classic mousse, despite its textural imperfections. On the other hand, our hedonic test results point to a formulation challenge: the granular texture imparted by the artichoke powder likely prevented the SA formulation from scoring as highly as the stevia-only version. This finding is consistent with previous studies on fiber-enriched products (Morais et al., 2015) and underscores the need for optimizations, such as different homogenization techniques or the use of emulsifiers, to improve mouthfeel.

A cost analysis to assess the industrial feasibility and economic sustainability of the formulations identified significant variations in raw material costs per serving. According to February 2024 data, the control (C) formulation was costed at 36.04 TRY, while the stevia-substituted (S) formulation was 38.14 TRY, and the functional formulation supplemented with artichoke powder (SA) was 60.08 TRY. The modest 6% cost increase associated with the stevia substitution is deemed commercially viable and aligns with market expectations for the "sugar-free" segment. The analysis's key finding, however, is that the incorporation of artichoke powder for functional enrichment elevated the cost by approximately 67% relative to the control. It is a well-established fact that functional ingredients, particularly high-purity extracts with proven bioavailability, increase the final product cost (Galanakis, 2021; Priyadarshini, Tiwari, & Rajauria, 2022). This substantial increase in cost prevents the SA formulation from competing on a price basis with traditional products and positions it as a high-value-added 'premium functional food'. Therefore, the commercialization potential of the formulation depends on reaching a niche, health-conscious consumer segment willing to pay a premium for the physiological benefits it provides, such as prebiotic fiber. The effective communication of this functional value to the consumer through a targeted marketing strategy is of critical importance for the product's market success.

Conclusion and Recommendations

This study successfully demonstrates that stevia can be used to create sensorially acceptable, sugar-free mousse formulations that are preferred over traditional sucrose-based recipes. The combination of stevia with artichoke powder presents a significant opportunity for developing functional desserts tailored for diabetic and ketogenic diets, offering both sweetness and prebiotic fiber. However, the study also highlights critical challenges related to texture and cost that must be addressed for successful commercialization.

Based on the specific findings and limitations of this research, the following focused recommendations are proposed for future work:

- The primary sensory challenge identified was the granular texture imparted by the artichoke powder, which negatively impacted the hedonic scores of the SA formulation. Future research should prioritize optimizing the mouthfeel of the fiber-enriched mousse. This could involve exploring different stabilization techniques such as advanced homogenization, the use of emulsifiers, or sourcing artichoke powder with a finer particle size to ensure a smooth texture without compromising its functional fiber content.
- While the formulation is designed to be diabetic and ketogenic-friendly based on its ingredients, this knowledge requires analytical validation. A critical next step is to conduct a detailed nutritional analysis of the final product to confirm its macronutrient profile, particularly its net carbohydrate, fiber, and caloric content. This data will provide the scientific basis to substantiate its health claims and support its positioning in the functional foods market.
- The significant cost increase associated with the artichoke powder positions the functional mousse (SA) as a premium product. To ensure market viability, it is crucial to conduct market research to determine the target consumer's willingness-to-pay for added prebiotic benefits. Concurrently, exploring more cost-effective alternative prebiotic fiber sources could enhance the product's commercial potential for a broader audience.

By addressing these key areas—texture, cost-viability, and nutritional validation—the promising concept developed in this study can be advanced into a successful and impactful functional food product.

Limitations

The primary limitations of this study are the restricted number of panellists and trial repetitions, which may constrain the statistical power of the findings. Additionally, the short duration of sensory evaluations has left gaps in understanding the acceptability of stevia's aftertaste in repeated consumption and its effects on satiety. The lack of analysis of critical parameters such as the glycaemic index of the product and its interactions with gut microbiota necessitates experimental validation of its functional properties.

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