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Sensory Profiling and Consumer Preference Analysis of Dark Chocolate Enriched with Algal Oil: A Comprehensive Evaluation

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Abstract: In terms of sustainable and equitable food security, the world is experiencing a number of issues due to the rapid increase in population. Given their fast growth rates and ability to survive in non-arable terrain, microalgae are seen to be one of the most promising feedstocks for a sustainable and reasonably priced supply of food and fuel. Algae being a rich and reliable source of fatty acid especially Omega-3. It was decided to create a dark chocolate with 12, 14, 16, and 18% algae inclusion. As the goods' amount of algal oil increased, so did their concentration of omega-3 fatty acids. The food industry is now experiencing a dramatic uptick in the novel products, improved quality, increased productivity, decreased production, and distribution costs, increased shelf life, and increased competition as a result of the gradual elimination of trade barriers and the expansion of global markets. Success in the face of these new challenges will depend heavily on the industry's capacity to get more precise information about consumer perceptions and attitudes that pertain to food items, and the most effective ways to quantify and apply them. The first stage in doing it is sensory evaluation. The product containing 18% algal oil had a more pronounced fishy taste and a stronger aroma. Ninety-two percent of the sensory panel approved of the chocolate containing algae oil. Every sample had an acceptability index more than 70%. At the amounts examined in this study, algae oil might be added to the dark chocolate to enhance any potential health advantages.

Keywords: Algae, Dark chocolate, Omega-3 fatty acid, Sensory evaluation.

I. Introduction

The creation of novel food products with enhanced quality and health advantages has drawn more attention lately. Products made from cocoa, particularly chocolate, have emerged as extraordinary food items for consumers' daily enjoyment and nutritional needs. Chocolate is defined as a continuous fat phase made of fine solid particles suspended in a semi-solid solution made of sugar and cocoa [1]. There are three primary categories of chocolate that is dark, milk and white, and their contents of milk fat, cocoa butter, and cocoa solids differ. The final products' protein, fat, and carbohydrate contents vary due to variations in the constituents' proportions. Given that high-cocoa chocolate contains magnesium and polyphenols, both of which are favorable for human health, the consumption of this food has been researched in this area. High concentrations of polyphenols (catechin, flavonols, epicatechin, and anthocyanins), which are known to be beneficial for cardiovascular disease, have been found in cocoa and dark chocolate [2].

Algal biomass-derived compounds have a wide range of potential applications, including animal and plant health, food and nutrition, and health products. Some of the substances found in these microorganisms have an anti-viral, anti-inflammatory, anti-helminthic, anti-microbial, and anti-cytotoxic properties, as well as immunological and enzyme inhibition properties. Microalgae and its compounds therefore have great potential to be used as supplements in human diets to prevent, manage, and treat physiological aberrations as well as to provide sustainable natural resources instead of synthetic dietary supplements. However, there are new biological and economic challenges to the large-scale microalgae cultivation and biorefining process that need to be addressed in order to produce high-value products of nutritional and health benefits sustainably [3]. Algal biomass or extracts from algae can serve as food components, fulfilling the requirements of customers for nourishing, environmentally friendly, and healthful food. Microalgae and macroalgae, sometimes known as seaweed, have a high concentration of polyunsaturated fatty acids, colours, vitamins, soluble fibers, proteins, polysaccharides, minerals and lipids [21]. Nevertheless, a significant obstacle in incorporating algae

into food systems is the issue of palatability. The reason for this is the existence of numerous odour-active volatile chemical compounds in algae biomass, which may be unpleasant for certain algal-food items [20].

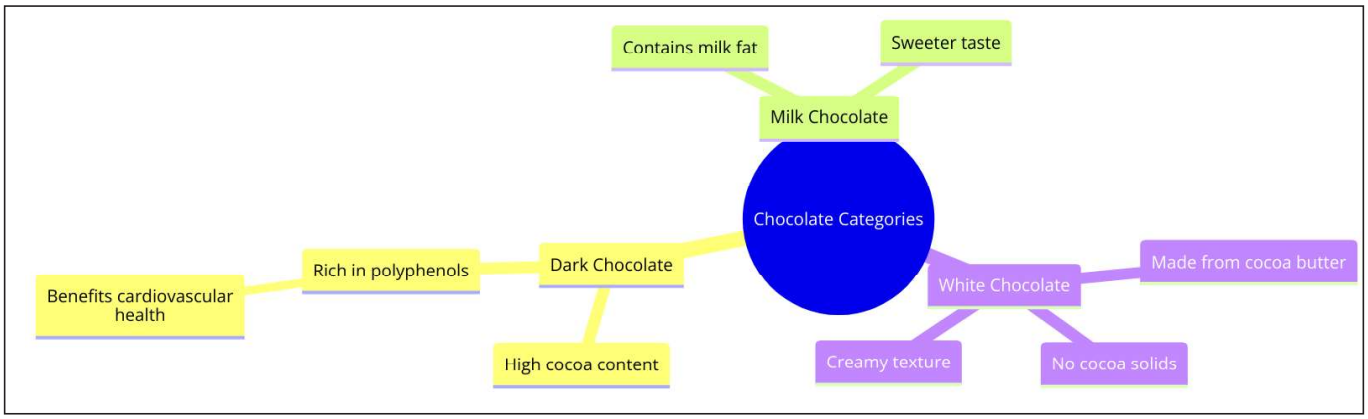

Fig. 1: Categories of Chocolate with Characteristics

Chocolate is a uniform product created by combining milk products, sugars, sweetners, additives, and derivatives of cocoa (Theobroma cacao L.). The cocoa solids content of chocolate varies depending on the kind, with a minimum of 25% for milk chocolate and 35% for dark chocolate. In order to produce additional chocolate goods, it is possible to incorporate ingredients other than flour, starch, and animal fats [19].

This work created a dark chocolate that also included algae oil. The purpose of this addition was to confirm that the chocolate's omega-3 content and quality had improved, to assess the samples' levels of polyphenols and omega-3, and to confirm that a sensory panel had approved of this.

II. Materials and Methods

Material Used: Dark chocolate compound, Butter, Jaggery, Coffee, Vanilla essence, Sesame seeds, Algal oil.

Sample Preparation: Samples of dark chocolate with algal oil: For the product's manufacture, dark chocolate (40% cocoa mass) was used. Four formulas with varying algal oil percentages (12, 14, 16, and 18%) were created. The compound chocolate was chopped, heated at temperature of 100 °C in a static bath with butter, and then hand tempered on a cool surface before adding Jaggery, At the specified percentages, coffee, vanilla essence, sesame seeds, and algae oil were added (as shown in Table I

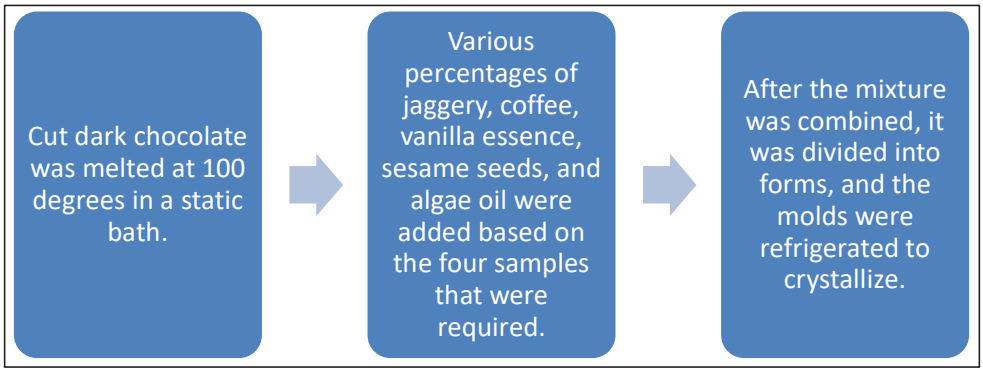

Fig. 2: Flowchart for the Product Development Process

Table I: Product Composition, Including Ingredients Quantity

Ingredients	*Sample A*	*Sample B*	*Sample C*	*Sample D*
Butter	16.612 g	16.612 g	16.612 g	16.612 g
Chocolate Compound	47.042 g	47.042 g	47.042 g	47.042 g
Jaggery	2.467 g	2.467 g	2.467 g	2.467 g
Algal oil	1.722 g	2.108 g	2.567 g	2.980 g
Sesame seeds		1.987 g		
Vanilla essence	2 drops	2 drops	2 drops	2 drops
Coffee	0.394 g	0.394 g	0.394 g	0.394 g

and Fig. 2). Following that, the mixture was put into forms and refrigerated at temperature of 3 °C till the developed chocolate samples were taken out of the molds (as shown in Fig. 1) [7].

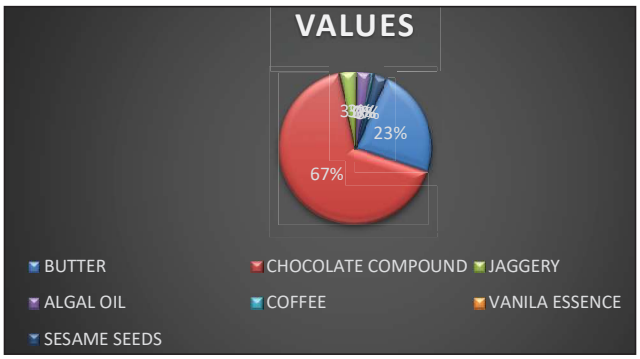

Fig. 3: Product Composition, Including Ingredient and Quantity in Percentage

Composition Analyses: Around twenty-five non-trained panelists were asked to evaluate the chocolate samples, using a 9-point Hedonic scale [9]. The criteria "dislike extremely" was associated with one end, "neither like nor dislike" with the center, and "like extremely" with the other end. The following equation was used to get the index of acceptance (IA):

$$IA = M/9 \times 100$$

where M denotes the average of the sensory panel's ratings [4] [17] [18]. The panelists were asked which sample they preferred, and the percentage of preference for each was computed in order to evaluate the preferences.

III. Result and Discussion

The results of the sensory evaluation using the 9-point Hedonic scale indicated that panelists liked Sample B better than the other prepared sample in terms of taste, texture, oral appeal, and fragrance. Based on the findings, it was determined that around 91% of the 25 panelists had a cumulative preference percentage when it came to preferring the chocolate with algae (as shown in Table II). The mean score was determined based on the panelists' analysis of the 9-point Hedonic scale (as shown in Table II). There were no discernible variations in the panelists' preferences across the samples with varying percentages of algal oil. Every formula displayed an acceptability index more than 50%.

Table II: Sensory Evaluation of the Chocolate Samples with Variations of Algal Oil Composition

Parameters	*Algal Oil Composition (%)*			
	12	*14*	*16*	*18*
Index of Acceptance, %	71.11	84.88	75.11	52.44
Preference, %	24	32	21	14
Mean Score (Hedonic Rating Scale)	6.41±0.64	7.64±1.29	6.76±1.82	4.72±1.08

Values followed by different superscripts differ considerably (n = 25 panelists)

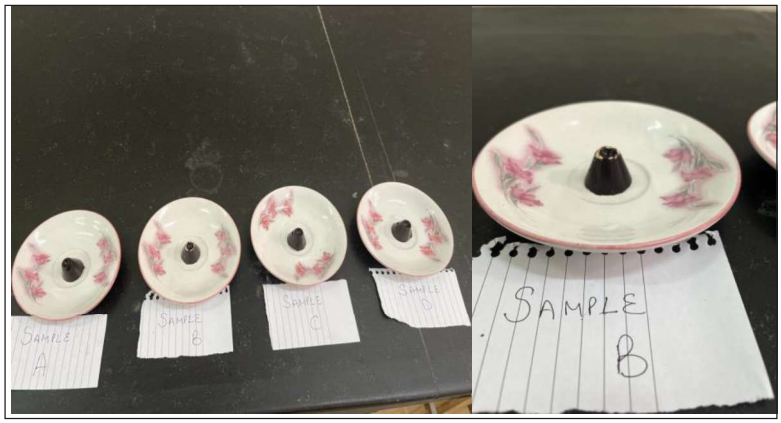

Fig. 4: Developed Algal Oil Chocolate Sample

IV. Conclusion

The food sector is a pivotal component of the global economy, playing a crucial role in the production, processing, and distribution of food products. Despite its significance, this industry faces several challenges, particularly in the realm of product innovation. Many new products fail to meet expectations, which highlights the complexities involved in understanding consumer preferences and market dynamics [5].

One of the most dynamic segments within the food industry is the functional foods sector. Functional foods are designed to

offer health benefits beyond basic nutrition, and their popularity is on the rise. This surge is fueled by increasing consumer health consciousness and advancements across various scientific disciplines, including nutrition and biotechnology. Despite the broad array of functional foods developed for nearly every food category, their market penetration varies significantly [10]. Consumer preferences can differ widely, affecting the distribution and success of these products in different demographic groups.

A recent study focused on the market acceptance of a new functional food product formulated with varying concentrations of algal oil. Algal oil is prized for its health benefits, including high levels of omega-3 fatty acids, which are essential for cardiovascular health and cognitive function. The study explored how different percentages of algal oil in the product (specifically 12%, 14%, 16%, and 18%) influenced consumer acceptance. Sensory evaluation was conducted to assess the appeal of each formulation. The results revealed a varied acceptance index: the product with 14% algal oil received the highest approval at 84.88%, followed by the 16% version at 75.11%, the 12% version at 71.11%, and the 18% version at 52.44%. This data suggests that there is a critical threshold beyond which increased concentrations of algal oil may negatively impact consumer perception and acceptance of the product.

These findings underscore the importance of consumer-driven innovation strategies in the food industry. Understanding consumer preferences and sensitivities can significantly enhance the success rate of new functional food products. As the market for functional foods continues to expand, manufacturers must fine-tune their product formulations to align with consumer expectations and preferences to ensure broad market acceptance and success [6].

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