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Development and Assessment of Sensory Properties of Spirulina Based Smoothie Premix

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ABSTRACT

The study evaluates the sensory and microbial qualities of spirulina-based smoothie premixes, focusing on different spirulina concentrations (T1, T2, T3) compared to a standard premix. Sensory evaluation highlighted T3 (6% spirulina) as the top-performing variant with a total score of 96, excelling in flavor and absence of defects. Microbial analysis showed no detectable growth initially, and minimal increases after 90 days, within acceptable limits. The findings suggest that incorporating spirulina enhances sensory attributes and maintains microbiological safety, with T3 offering the most promising results and a potential shelf life of 90 days.

Keywords: Spirulina, Smoothie, Premix, Antioxidants, Nutritive values, Platensis, Arthrospira.

1. Introduction

Spirulina (Arthrospira sp.) is a microalga that has been consumed for centuries by indigenous peoples in Mexico and northern Africa. The alkaline lakes found in those regions are its natural habitat. Spirulina belongs to the phylum cyanobacteria, and the term covers two species of microalgae are Arthrospira platensis and Arthrospira maxima. Both are used in the production of food and dietary supplements. Spirulina can oxygenic photosynthesis and reproduces asexually by binary fission until it reaches maturity. The protein content of Arthrospira is as high as 70%, and it is a protein of high biological value, due to its content of all essential amino acids in the proportions recommended by the FAO (Food and Agriculture Organization). Consequently, it is superior to other plant sources of protein and as valuable as eggs, meat, and milk. The content of polyunsaturated fatty acids (PUFAs), such as eicosapentaenoic acid (EPA) and (DHA). It is also important to mention the vitamin content-A, D, E, K, and group B vitamins. The high content of vitamin B12 makes spirulina particularly valuable for vegans and vegetarians who, due to the lack of meat products in their diet, may be at risk of deficiencies of this vitamin. Spirulina is a good source of mineral nutrients such as Calcium, Phosphorus, Iron, Zinc, Magnesium, Potassium, Sodium, Iodine, and Manganese. It contains high amounts of carotenoids (astaxanthin, zeaxanthin, and β-carotene), polyphenols, and chlorophyll. With such a plethora of bioactive compounds, antioxidant, anti-inflammatory a immunomodulatory properties. It has also been found to inhibit the activity of viruses, including HIV and influenza viruses. The antioxidant effects of spirulina can be attributed to its ability to regulate antioxidant enzymes, such as superoxide dismutase, catalase, and glutathione peroxidase. Spirulina is relatively low in calories, making it an attractive option for those seeking a nutrient-rich, low-calorie supplement. Spirulina is an excellent source of plant-based protein, containing all essential amino acids. Spirulina is a powerhouse of nutrients, containing proteins, vitamins (especially B vitamins), minerals (such as iron and magnesium), and antioxidants. As a photosynthetic bacterium, Spirulina utilizes sunlight to produce energy through photosynthesis. Rapid Growth: Spirulina has a high growth rate, making it a sustainable and efficient source of nutrition **(Akshita Sharma, et.al.,2019).**

Spirulina, a nutrient-rich blue-green algae, is commercially farmed for its superfood status. While Hawaii is a major producer, Asia-Pacific dominates, with China and India leading the way. Cultivation can occur in open ponds or closed systems, mimicking Spirulina's natural warm, alkaline environment. Sunlight is crucial for its growth, making spirulina farming an eco-friendly process. Companies like Muragappa Chettir (India) and Earthrise Farms (USA) are among the global leaders in this sustainable superfood production (**Edis Koru 2012).**

2. Materials and methods

- The raw ingredients dry fruits, jaggery and milk powder were purchased from the local market of Lucknow and processed in the food science laboratory of Babasaheb Bhimrao Ambedkar university Lucknow.
- Spirulina powder was purchased from Heilen Biopharm Pvt. Ltd. Ahmedabad, Gujarat, India.

- The preparation of the spirulina-based smoothie premix was performed in the Food Science Laboratory of school of home science of Babasaheb Bhimrao Ambedkar university Lucknow, Uttar Pradesh, India.

2.1 Ingredients used

A combination of Spirulina powder, Milk Powder, jaggery and dry fruits such as including Almond, cashew, pista, and dates has been utilized to Develop a spirulina-based smoothie premix.

Table 1 – The percentage of ingredients used to develop the spirulina-based smoothie premix

Premix (100g)	**Standard**	**T1**	**T2**	**T3**
Jaggery powder	10g	10g	10g	10g
Milk powder	76g	70g	70g	70g
Dry fruits powder	14g	18g	16g	14g
Spirulina powder	-	2g	4g	6g

2.2 Preparation of standard smoothie premix

The raw ingredients, including milk powder, almonds, cashews, dates, pistachios, and jaggery, were gathered. The preparation of the standard smoothie premix involves combining 76% milk powder, 14% dry fruit powder, and 10% jaggery powder. The moisture content of the dry fruits is decreased through roasting. Using a mixer, the dry fruits and jaggery are processed into a powder. The ingredients are then thoroughly mixed to ensure even distribution. Finally, the prepared standard smoothie premix is packed into an airtight container.

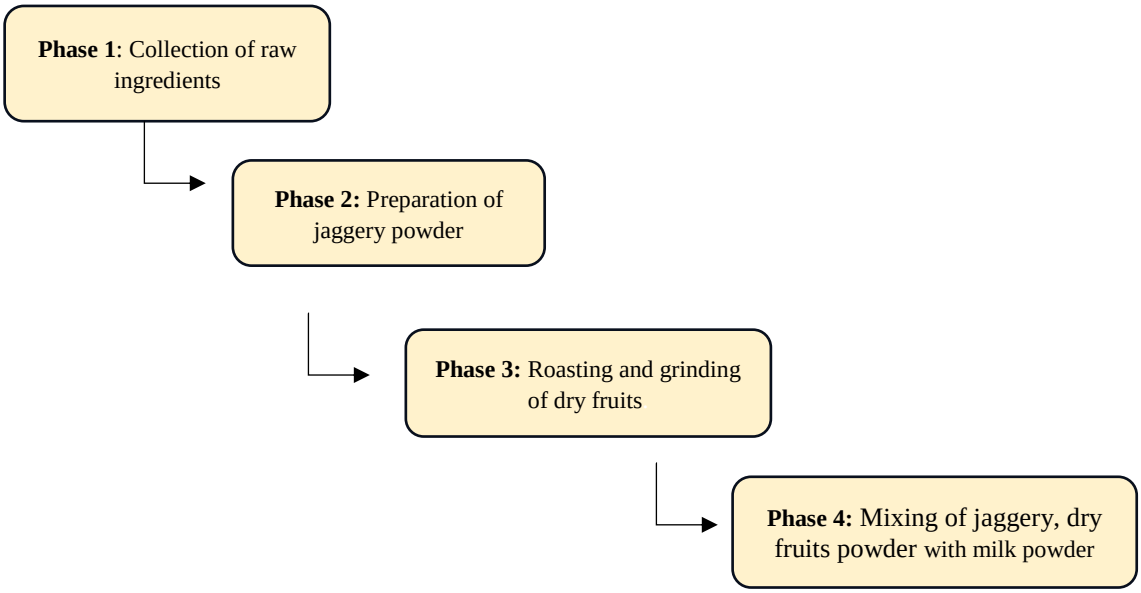


Fig 1: flow chart of preparation of standard smoothie premix.

2.3 Preparation Spirulina-based Smoothie Premix treatments

The process starts with the collection of prepared standard premix and Spirulina powder. The standard premix likely consists of a premix of various dry ingredients, such as milk powder, dry fruits powder, and jaggery powder formulated to create a base for the final product. To enhance the nutritional value of the standard premix, Spirulina powder is added in three different variations: 2%, 4%, and 6%. These variations allow for flexibility in creating different formulations with varying levels of Spirulina content, catering to different preferences or nutritional requirements. Once the Spirulina powder is measured out according to the desired variation, it is carefully incorporated into the standard premix. Mixing is crucial at this stage to ensure that the Spirulina powder is evenly distributed throughout the premix. This step guarantees consistency in colour and nutritional content. After thorough mixing,

the prepared spirulina-based smoothie premix is ready for packaging. The premix is packed into an air-tight container to maintain its freshness and prevent exposure to moisture and external contaminants.

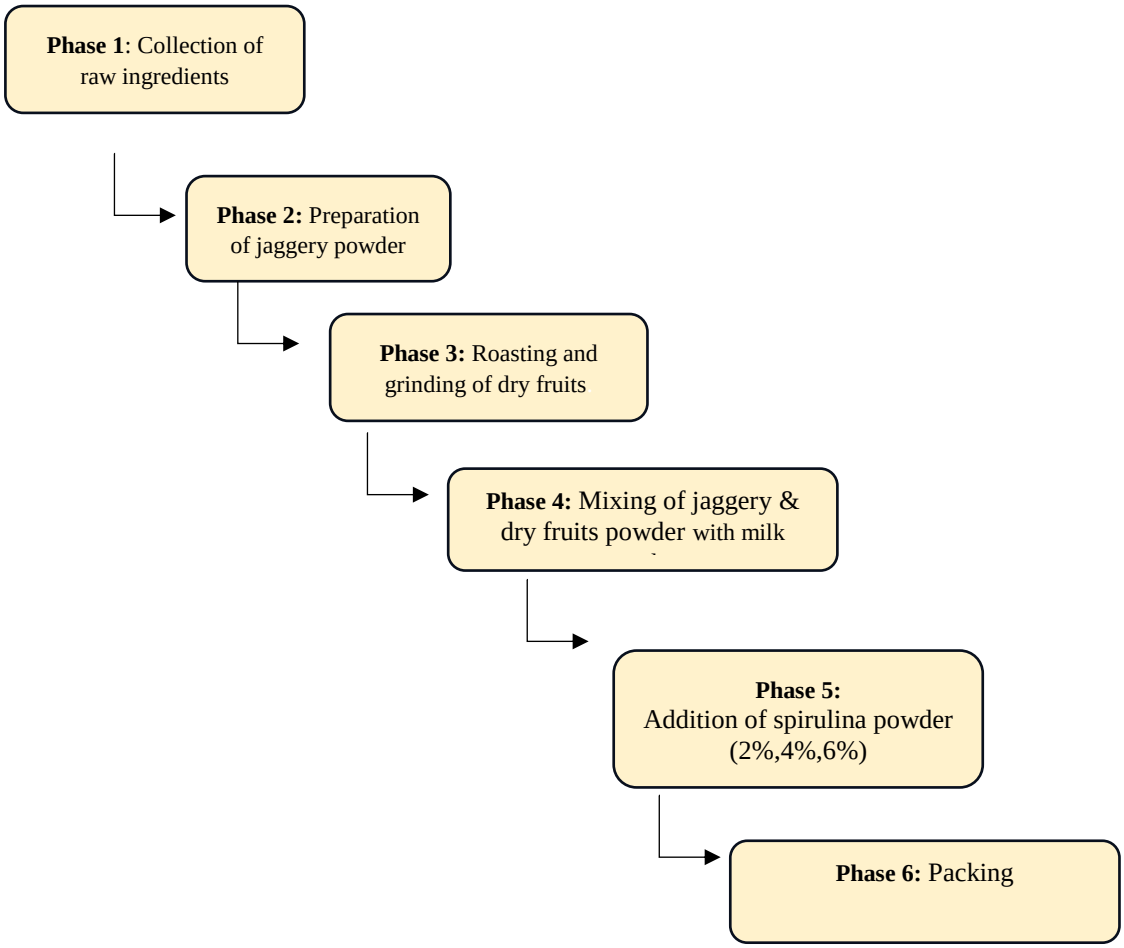


Fig 2: Flow chart of preparation of spirulina-based smoothie premix

Fig 3: Steps of preparing spirulina-based smoothie premix

2.3 Sensory evaluation of Spirulina-based smoothie premix

A composite sensory table was utilized for organoleptic evaluation, which was carried out by a team of trained panel members. The sensory scores of the standard sample, T1, T2, and T3 were evaluated by a total of 20 panel members. Among them, T3 received the highest average score of 96/100, surpassing T1 and T2. The evaluation process involved the use of a highly advanced composite sensory table, which was specifically designed to carry out organoleptic evaluations. The panel members who conducted the evaluations were carefully selected and extensively trained in sensory analysis. The sensory characteristics of the standard sample, T1, T2, and T3 were meticulously evaluated, taking into account their colour, absence of defects, flavour, and consistency. The evaluations were carried out by 20 panel members, each of whom brought their unique expertise and perspective to the process.

Fig 4: Sensory evaluation

2.4 Microbial study of prepared spirulina-based smoothie premix

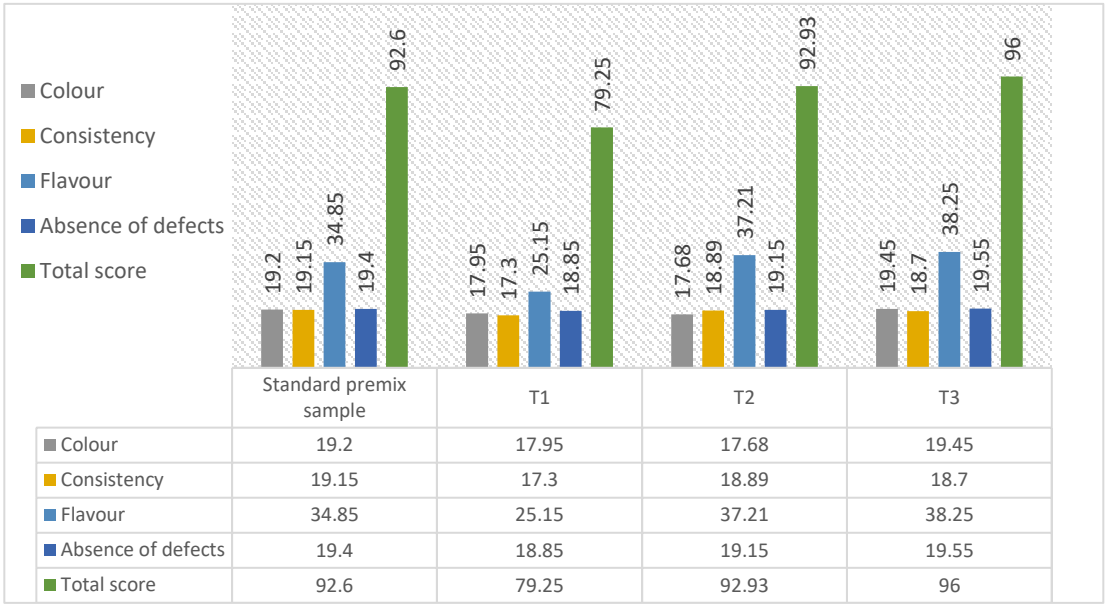
The total plate count method is a perfect protocol for performing microbial analysis to examine microbial contamination in food products. The spirulina smoothie premix's total plat count was determined using nutrient agar-containing. The dilutions were made up to 10^{-4} and 0.1 ml of aliquot was used for the isolation. Laminar airflow was used to facilitate the completion of every procedure in a sterile environment. Obtain samples of the spirulina-based smoothie premix at the initial point (0 days) and after 90 days of storage. Prepare the samples according to standard protocols, ensuring representative portions are taken for analysis. At 0 days: Conduct a total plate count analysis to determine the total viable microbial load present in the sample. After 90 days: Repeat the total plate count analysis to assess any changes in microbial levels due to storage. At 0 days Perform a yeast and mould count analysis to identify and quantify any yeast and mould contaminants present. After 90 days: Repeat the yeast and mould count analysis to evaluate changes in yeast and mould levels over the storage period. Analyze the obtained data to determine the microbial levels present in the spirulina-based smoothie premix at both time points.

Fig 5: Microbial Analysis

3. Results:

3.1 Sensory Evaluation

Fig 6 reveals the sensory evaluation variations in the quality of Spirulina smoothie premix, with T1 scoring the lowest total score of 79.25 out of 100. T1 exhibits lower scores across all attributes compared to the standard smoothie premix and other variants. Notably, T2 demonstrates a significantly higher score in flavor (37.21) compared to the other variants, contributing to its total score of 92.93. However, T3 emerges as the top-performing variant with a total score of 96, excelling particularly in flavor (38.25) and absence of defects (19.55). Fig-3 reveals the organoleptic evaluation of these findings suggests that T3 offers the most appealing sensory experience among the evaluated smoothie premixes, with its balanced combination of Colour, Consistency, Flavour, and absence of defects.



	Standard premix sample	T1	T2	T3
Colour	19.2	17.95	17.68	19.45
Consistency	19.15	17.3	18.89	18.7
Flavour	34.85	25.15	37.21	38.25
Absence of defects	19.4	18.85	19.15	19.55
Total score	92.6	79.25	92.93	96

Fig 6: Graphical representation of Sensory Acceptability of Respondents.

3.2 Microbial Analysis:

Total viable counts were used to measure Microbiological quality concerning the level of general microbial contamination. The microbial analysis of the spirulina-based smoothie premix revealed the absence of detectable microbial growth at the initial point (0 days). However, after 90 days of storage, there was a slight increase in both total plate count and yeast and mould count, with values of 1 cfu/g and 1 cfu/g, respectively. While these counts are relatively low and generally considered acceptable for food products, they indicate some microbial activity or contamination over the storage period. Microbiological studies were conducted for the best Spirulina smoothie premix sample. There were microbial colonies formed after 90 days of storage in

the 6% Spirulina smoothie premix sample was within the acceptable range. Based on the initial microbial analysis results and assuming that the product maintains its sensory quality over time, an estimated shelf life of around 90 days could be considered.

Table 2: Result of Microbial Analysis

Storage period	**Total plate count (cfu/g)10^3**	**Yeast and Mould (cfu/g)10^3**
0	0	0
90 days	1	1

4. Conclusion

Based on the findings from this study, it can be concluded that the development of a spirulina-based smoothie premix was successful in enhancing both nutritional content and sensory attributes. The incorporation of spirulina into the premix at varying concentrations (2%, 4%, and 6%) demonstrated significant impacts on sensory characteristics, particularly in terms of flavour and overall acceptability. Among the formulations tested, the premix containing 6% spirulina (T3 sample) achieved the highest sensory score of 96, indicating superior sensory properties compared to lower concentrations. The microbial analysis conducted throughout the study confirmed the microbiological safety and stability of the spirulina-based smoothie premix. The initial absence of detectable microbial growth and the minor increase in microbial counts after 90 days of storage (1 cfu/g for both total plate count and yeast & Mold count) suggest that the product maintains acceptable microbial quality throughout its shelf life. The spirulina-based smoothie premix developed in this study offers a promising functional food option. Its favourable sensory attributes and microbial stability make it a viable choice for consumers seeking nutritious and safe dietary supplements. Future research could focus on exploring additional applications or optimizing formulations to further enhance nutritional benefits and extend shelf life under various storage conditions.

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