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Formulation of star fruit (*Averrhoa carambola* L.) powder unified digestive food products and their quality evaluation

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Abstract

It's unfortunate that *Averrhoa carambola*, commonly known as star fruit, is considered an underutilized fruit in India due to its perishable nature and higher moisture content. This can indeed lead to significant food waste and missed economic opportunities for farmers and producers. However, there are several potential strategies that can be explored to reduce waste and promote the consumption of star fruit in India. Star fruit is one of the tropical fruit that has usual less consideration from the food industry. A large number of ripened star fruits gone wasted during the fruiting-season. Consequently, a study was conducted to develop food products, evaluate nutritive value and sensory characteristics from highly nutritious underutilized fruit. Star fruit powder were used in different ratio *i.e.* 10percent, 20percent, 30percent, 40percent and 50percent with other ingredients for the development of value added products. Several preliminary trials were conducted to standardize star fruit powder and finally therefore T4 (40% Star fruit powder incorporation) was found acceptable. Star fruit products (*Laddu*, *Hingoli*) products were compared with control and found that overall acceptability of star fruit was more than compared control. Vitamin C content was significantly higher in star fruit products compared to control.

Keywords: Star fruit, underutilization, preliminary trials, nutritive value, sensory evaluation

Introduction

Absolutely, garden-fresh fruits and vegetables are an essential part of a healthy diet and play a crucial role in promoting good health. Here are some key reasons why they are considered imperative. India's diverse climate indeed contributes to the availability of a wide variety of fresh fruits and vegetables throughout the year. The country's geographical diversity, with regions ranging from tropical to temperate, allows for the cultivation of a vast array of produce. Star fruit (*Averrhoa carambola*) is one such tropical fruit that can be found in India. India's position as the second-largest producer of fruits in the world is indeed significant, with a production of 82.632 million tonnes as of the information provided. However, the high post-harvest losses ranging from 17 to 35 percent are a cause for concern. These losses occur during various stages of the fruit supply chain, including handling, transportation, storage, processing, and distribution. Here are some factors contributing to these post-harvest losses.

Incorporating a variety of fresh fruits and vegetables into your daily diet is an excellent way to ensure you receive a wide range of nutrients and promote overall health. It's recommended to aim for a colorful and diverse plate of fruits and vegetables to maximize the health benefits they offer. Overall, star fruit's versatility, appealing appearance, and nutritional value make it a valuable addition to both local and international cuisines. Its popularity as both a fresh fruit and an ingredient in various culinary preparations highlight its importance in promoting culinary diversity and healthy eating habits (Avinash *et al.* 2010) [2].

Starfruit can be consumed in two stages – when it is still green and unripe, it can be used in savory dishes, often cooked or pickled as a vegetable. When it ripens, it turns yellow and is enjoyed as a sweet and juicy fruit. Starfruit, scientifically known as *Averrhoa carambola*, is indeed a versatile fruit with various culinary and potential medicinal uses. Here are some key points about starfruit and its potential health benefits. Edible as Both Vegetable and Fruit: **Nutritional Value:** Starfruit is rich in nutrients such as vitamin C, vitamin A, potassium, and dietary fiber. It is low in calories, making it a healthy addition to your diet.

Traditional Medicine: Throughout history, various parts of the starfruit tree, including the leaves, fruit, and roots, have been used in traditional medicine for their potential health benefits.

Anti-Inflammatory: Star fruit contains compounds with anti-inflammatory properties that may help reduce inflammation in the body.

Analgesic: It has been used as a pain reliever in some traditional medicinal practices.

Hypotensive: Some studies suggest that starfruit may help lower blood pressure due to its potassium content.

Anthelmintic: Starfruit has been used to treat parasitic infections.

Antioxidant: It contains antioxidants that can help neutralize harmful free radicals in the body.

Anti-Ulcer: Some research has shown potential for starfruit to have anti-ulcer properties.

Hypocholesterolaemia and Hypolipidemic: Starfruit may help lower cholesterol levels and reduce lipid levels in the blood, which can contribute to heart health.

Antimicrobial: It may possess antimicrobial properties that can help combat certain infections.

Anti-Tumor Activities: While some studies have suggested anti-tumor properties, more research is needed in this area.

Diabetes: Starfruit's potential benefits for people with diabetes are a topic of interest. It contains fiber and antioxidants, which can help regulate blood sugar levels. However, it's important for individuals with diabetes to consume starfruit in moderation due to its natural sugar content, as excessive consumption can lead to adverse effects.

Heart Health: Due to its ability to lower cholesterol and blood pressure, starfruit may contribute to reducing the risk of heart disease and stroke. Again, moderation is key, as excessive consumption can be harmful to those with certain health conditions.

It's essential to note that while starfruit has many potential health benefits, it can be problematic for individuals with kidney issues or those taking specific medications. Starfruit contains a substance called oxalate, which can lead to kidney problems in susceptible individuals. Always consult with a healthcare professional before making significant dietary changes or incorporating starfruit into your diet, especially if you have underlying health conditions.

Starfruit's antioxidant capacity is attributed to its rich content of vitamin C and other phytochemicals, such as flavonoids and polyphenols. These antioxidants play a crucial role in protecting cells from oxidative damage, which is associated with various chronic diseases and aging. (Amitabha *et al.* 2003) [1]. Adding fruits to your diet can help lower cholesterol, maintain blood pressure, and manage body weight. (Budhwar, 2008) [3]. This fruit has the potential to be a great source of antioxidants due to its high levels of phenolic antioxidants. (Saghir *et al.* 2013) [7]. This fruit has anti-inflammatory activity, anti-ulcer activity hypoglycaemic activity as well as antimicrobial activity. Based on the nutraceutical properties of Star fruits and to prevent spoilage, they can be processed into a range of products such as jams, candy, pickles, and dried powder. Incorporating this fruit into our diet can provide approximately 30% of our daily requirement of Vitamin C in just 100g (Cabrini *et al.* 2011 and Ferreira *et al.* 2008) [4,5],

Materials and Methods

Procurement of raw materials

Ingredients including star fruit, wheat flour, sugar, Amla, Imli, salt, and ghee were acquired in a single purchase from the local market of Akbarpur, Ambedkarnagar Uttar Pradesh.

Star Fruit Food products such as *Laddu* and *Hingoli* were created by substituting star fruit powder with beetroot. Various blends were made using different ratios of star fruit powder and other ingredients, including 100:00, 90:10, 80:20, 70:30, 60:40, and 50:50. The procedures for preparing the star fruit products were followed as outlined in the accompanying Figure and Table.

Processing of Star Fruit and development of powder

To prepare the star fruit, it was first washed to remove any dirt or debris. Then, it was cut into small chips before being dried. The chips were spread out in a single layer on a drying sheet and placed in a hot air oven for 24 hours, at a temperature between 60°C and 80°C. Finally, the dried star fruit chips were ground using a grinder (as shown in Figure 1 and plate 1).

Standardization of *Laddu*: *Laddu* is a beloved traditional sweet that comes in the shape of balls and offers a variety of flavors depending on the ingredients used. The most common types are *Besan Laddu* and *Moti Choor Laddu*, which are made with wheat flour, sugar, and milk. *Laddu* is often served during special occasions like *Raksha Bandhan* and *Diwali*. To create *Star Fruit Laddu*, wheat flour is replaced with *Star Fruit Powder*. A total of six types of *Laddu* were developed using the standard method with slight modifications. Table 1, Figure 2, and Plate 2 provide all the details on the ingredients used to make *Laddu*.

Standardization of *Hingoli*: *Hingoli* is a blend of natural and organic herbs and spices in just the right proportion. *Hing*, one of the key ingredients, is known for its beneficial qualities, such as being anti-flatulent, antimicrobial, anti-inflammatory, anthelmintic, laxative, and expectorant. *Tamarind* and starfruit powder are also included in *Hingoli*, which are derived from the fruit of the tamarind and star fruit. *Tamarind candy*, a chewy treat that is coated in sugar, is often sold in small containers and can be seen in Table 2, Figure 3, and Plate 3.

Evaluation of sensory characteristics

A panel of ten semi-trained members from the Department of Foods and Nutrition evaluated the sensory characteristics of various products. The panelists were required to assess the products based on their color, flavor, taste, texture, appearance, and overall acceptability using a nine-point Hedonic scale and scorecard method. Table 3, provided by Srilakshmi in 2019, showcases the sensory characteristics evaluation of different products.

Nutrient calculation

Nutrients of developed products was calculated by using Nutritive value of Indian foods (NIN, 2017).

Results and Discussion

Sensory evaluation of star fruit powder added *Laddu*

Table 4 and Figure 4

Table 4 and Figure 3 present the results of the sensory evaluation conducted on *Laddu* prepared with different levels of star fruit powder (10%, 20%, 30%, 40%, and 50%) mixed with wheat flour, as well as a control sample. The highest scores were observed for all sensory characteristics in the control sample, with an overall acceptability score of

8.32±0.07, indicating that the panel members "liked it very much." Among the treatments, *Laddu* prepared with 40% star fruit powder (T4) scored the highest for all sensory characteristics, with an overall acceptability score of 8.57±0.17 compared to the other samples. T4 scored 8.53±0.12 for color, 8.43±0.06 for flavor, 8.50±0.17 for taste, 8.70±0.25 for texture, 8.60±0.00 for appearance, and 8.57±0.16 for overall acceptability, ranging from "moderately liked" to "liked very much."

As the level of star fruit powder increased, a decrease in sensory attributes was observed. However, when star fruit was added to *Laddu*, the sensory score indicated that the control option was most preferred, followed by T4, T3, T2, T1, and T5. This suggests that the addition of star fruit powder increased sensory scores by up to 40% when incorporated by 40%.

Sensory evaluation of star fruit powder added Hingoli Table 5 and Figure 5

This report presents the results of the evaluation of star fruit powder from Hingoli at different levels. The sensory score indicated that the star fruit powder falls under the category of "like very much" to "like moderately". The data in Table 4 shows that T4 (40%) received the highest scores for color, flavor, taste, texture, appearance, and overall acceptability, with a score of 8.53±0.12, 8.50±0.11, 8.46±0.12, 8.50±0.05, 8.56±0.16, and 8.51±0.08, respectively, compared to other treatments. From an overall acceptability standpoint, T3 (30%) scored the highest 8.51±0.08, followed by 7.93±0.18 for T1 (10%), 7.80±0.12 for T2 (20%), 7.90±0.23 for T3 (30%), and 7.80±0.12 for T6 (60%).

However, for all other sensory attributes, a decrease was noted in the score with an increase in the level of the star fruit powder ratio. The sensory scores ranged from "like moderately" to "like very much". The results of the sensory scores obtained for the star fruit powder from Hingoli indicated that the control was "liked very much" on an overall basis, followed by T4, T1, T2, T3, T5, and T6, respectively. The sensory scores increased up to a 40% ratio level, but then they continuously decreased with T1, T2, T3, and T5. Therefore, T4 Hingoli of star fruit powder was selected for further study.

Nutrient calculation of selected products

The nutritional composition provides information about the components and quality of a product. Below are the results of proximate and mineral contents.

Nutrient composition of *Laddu* Table 6 and figure 6

The nutrient composition of Star fruit *Laddu* has been presented in table and figure 6 on a dry weight basis of 100 grams. The data clearly shows that the Star fruit biscuit contains 11.49% protein, 13.76% fat, 2.24% ash, 1.9% fiber, 72.94% carbohydrates, 461.56 kcal energy, 84.44mg calcium, 6.41mg iron, 352.26mg phosphorus, and 13.42mg vitamin C per 100 grams. On the other hand, Control *Laddu* contains 7.58% protein, 13.3% fat, 2.26% ash, 1.16% fiber, 62.3% carbohydrates, 300.17% energy, 74.04mg calcium, 4.95mg iron, and 230.93mg phosphorus per 100 grams. The increase

in nutrient content of the star fruit biscuit was due to the incorporation of star fruit powder in the product compared to the control.

Nutrient composition of Hingoli Table 7 and figure 7

According to Table 7, Hingoli had 2.92% protein in T4 and 2.06% in the Control group. The ash content was 3.44% and 2.19% respectively. The Fibre content in the Control group was 5.31% and in the Hingoli with added star fruit powder, it was 4.31%. The fat content was 0.24% for the Control group and 0.15% for the Hingoli with added star fruit powder. The carbohydrate content was 42.21% for the Control group and 67.35% for the Hingoli with added star fruit powder. The energy value for the Control group was 179.31 kcal and for the Hingoli with added star fruit powder, it was 282.43 kcal. This indicates a slight increase in comparison to the Control group.

Table 1: Composition of *Laddu* prepared By Using star fruit powder

S.NO	Ingredients	Treatments					
		Control (T0)	T1	T2	T3	T4	T5
1.	Wheat flour	100 g	100 g	100 g	100 g	100 g	100 g
2.	Starfruit powder	00	10 g	20 g	30 g	40 g	50 g
3.	Jaggery	50 g	50 g	50 g	50 g	50 g	50 g
4.	Ghee	15 g	15 g	15 g	15 g	15 g	15 g
5.	Ginger power	10 g	10 g	10 g	10g	10 g	10g

Table 2: Composition of Hingoli prepared By Using star fruit powder

S. NO	Ingredients	Treatments						
		Control (T0)	T1	T2	T3	T4	T5	
1.	Tamarind(pulp)	100 g	90 g	80 g	70 g	60 g	50 g	
2.	Star fruit powder	-	10 g	20 g	30 g	40 g	50 g	
3.	Asafetida	2 g	2 g	2 g	2 g	2 g	2 g	
4.	Red chilli powder	1 g	1 g	1 g	1 g	1 g	1 g	
5.	Jaggery	100 g	100 g	100 g	100 g	100 g	100 g	
6.	Black salt	5 g	5 g	5 g	5 g	5 g	5 g	
7.	Sugar powder	As needed						
8.	Cumin seed powder	5 g	5 g	5 g	5 g	5 g	5 g	

Table 3: Score card for Organoleptic Evaluation

Date: Name of the Product

No	Name of the Judges	Characteristics					Over all acceptability
		Appearance	Colour	Flavour	Taste	Texture	
1							

Note: Fill score in columns according to your evaluation of given sample. Scoring is done on 9 point hedonic scale; scores are viz. Like extremely (9), Like very much (8), Like moderately (7), Like slightly (6), Neither like or dislike (5), Dislike slightly (4), Dislike moderately (3), Dislike very much (2), Dislike extremely (1) Evaluation of the product was done on the basis of 9 point hedonic scale. The test sample was given in triplicates with control. Control sample was prepared from the usual recipes. All samples were coded to avoid any type of biasness.

Table 4: Mean acceptability scores of star fruit powder added *Laddu*

Treatment	Colour Mean± SD	Flavour Mean± SD	Taste Mean± SD	Texture Mean± SD	Appearance Mean± SD	Overall acceptability Mean± SD
Control (T0)	8.20±0.00	8.43±0.13	8.20±0.05	8.33±0.12	8.46±0.08	8.32±0.07
T ₁ (10%)	7.70±0.15	7.70±0.11	7.76±0.08	7.76±0.29	7.90±0.15	7.76±0.14
T ₂ (20%)	8.10±0.25	8.13±0.14	8.13±0.13	8.23±0.13	8.40±0.15	8.16±0.12
T ₃ (30%)	8.06±0.03	8.13±0.16	8.10±0.10	8.20±0.17	8.26±0.06	8.15±0.09
T ₄ (40%)	8.53±0.12	8.43±0.14	8.50±0.17	8.70±0.25	8.60±0.15	8.57±0.16
T ₅ (50%)	8.16±0.23	8.10±0.20	7.96±0.06	8.23±0.03	8.20±0.05	8.13±0.08
C.D.	N/A	0.483	0.344	N/A	0.372	0.368
C.V.	3.443	3.289	2.361	3.941	2.490	2.501

Table 5: Mean acceptability scores of star fruit powder added Hingoli

Treatment	Colour Mean± SD	Flavour Mean± SD	Taste Mean± SD	Texture Mean± SD	Appearance Mean± SD	Overall acceptability Mean± SD
Control(T0)	7.70±0.17	7.80±0.17	7.86±0.23	7.73±0.26	8.03±0.18	7.82±0.20
T1(10%)	7.86±0.18	7.83±0.21	7.93±0.14	7.93±0.20	8.10±0.17	7.93±0.18
T2(20%)	7.76±0.08	7.80±0.17	7.70±0.15	7.83±0.14	7.90±0.100	7.80±0.12
T3(30%)	7.86±0.12	7.83±0.203	7.80±0.23	7.93±0.29	8.06±0.31	7.90±0.23
T4(40%)	8.53±0.12	8.50±0.11	8.46±0.12	8.50±0.05	8.56±0.16	8.51±0.08
T5(50%)	7.76±0.08	7.80±0.17	7.70±0.15	7.83±0.14	7.90±0.10	7.80±0.12
C.D.	N/A	N/A	N/A	N/A	N/A	0.534
C.V.	4.019	4.429	3.947	5.476	4.536	3.749

Table 6: Nutrient composition of *Laddu* (100 g)

Nutrient constituents	Control	T4 (40%)
Protein(g)	7.583	11.49
Fat(g)	13.30	13.76
Ash (g)	2.264	2.24
Fibre (g)	1.16	1.9
CHO(g)	62.36	72.94
Energy (kcal)	300.17	461.56
Calcium (mg)	74.04	84.44
Iron (mg)	4.95	6.41
Phosphorus (mg)	230.93	352.26
Vitamin C (mg)	-	13.42

Table 7: Nutrient composition of Hingoli (100 g)

Nutrient constituents	Control	T4 (40%)
Protein(g)	2.06	2.92
Fat(g)	0.24	0.15
Ash (g)	2.19	3.44
Fibre (g)	4.31	5.31
CHO	42.21	67.35
Energy (kcal)	179.31	282.43
Calcium (mg)	142.9	149
Iron (mg)	7.81	9.16
Phosphorus (mg)	105.06	113
Vitamin C (mg)	2.17	14.62

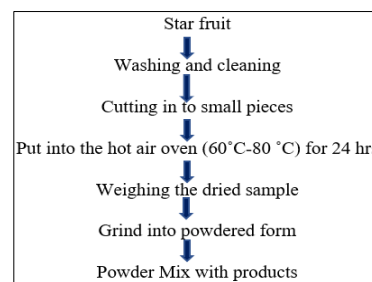


Fig 1: Preparation of Star fruit Powder

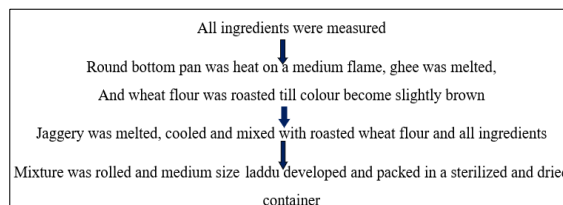


Fig 2: Flow chart for standardization of *Laddu*

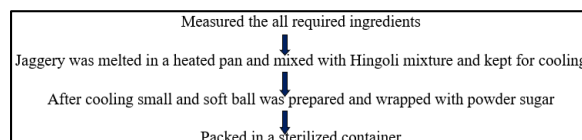


Fig 3: Flow chart for Star fruit powder added Hingoli



Plate 1: Star Fruit Processing

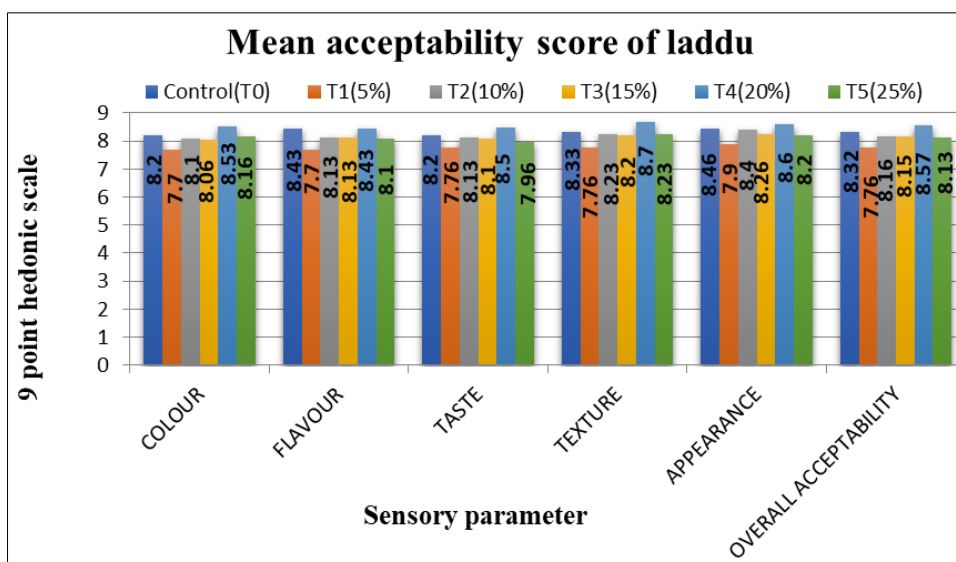


Fig 4: Mean acceptability score of star fruit powder added Laddu

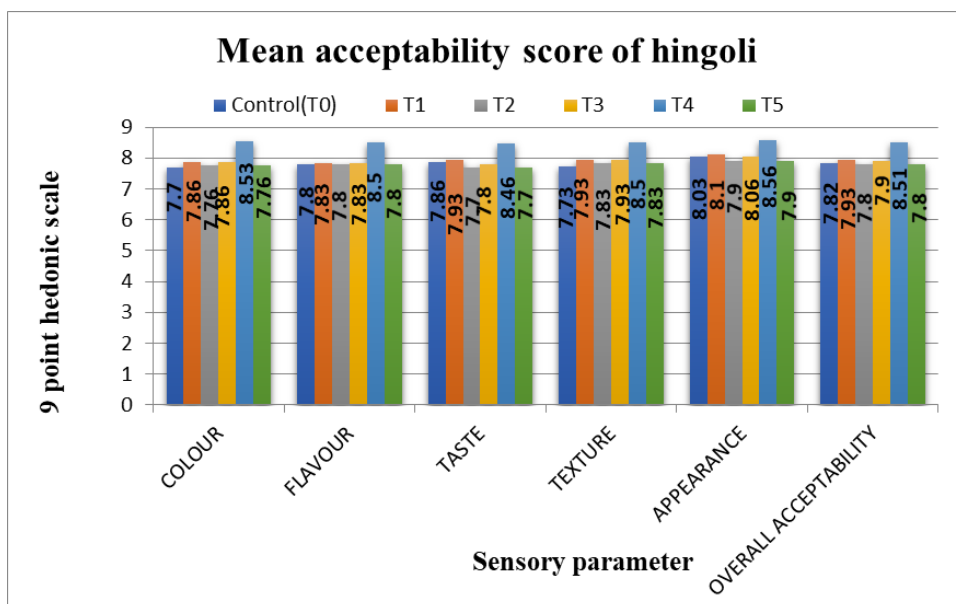


Fig 5: Mean acceptability score of Starfruit powder added Hingoli

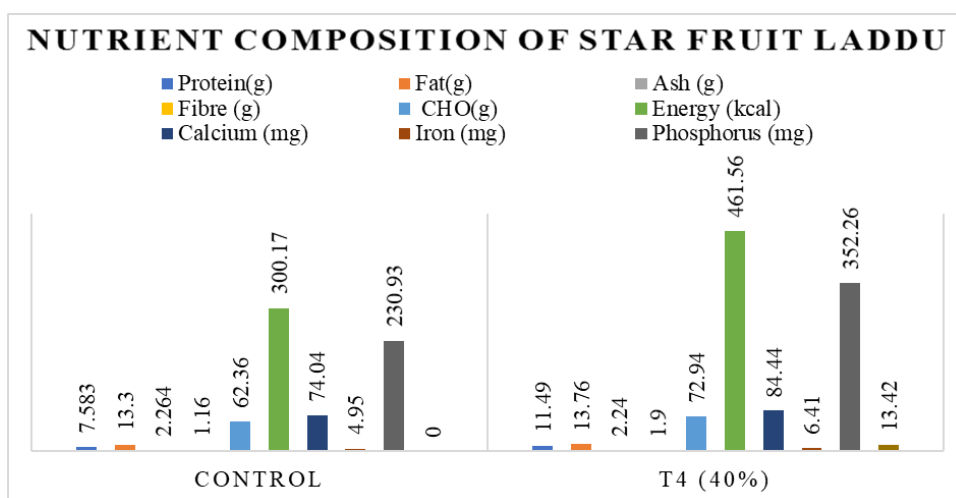


Fig 6: Nutrient composition of Laddu

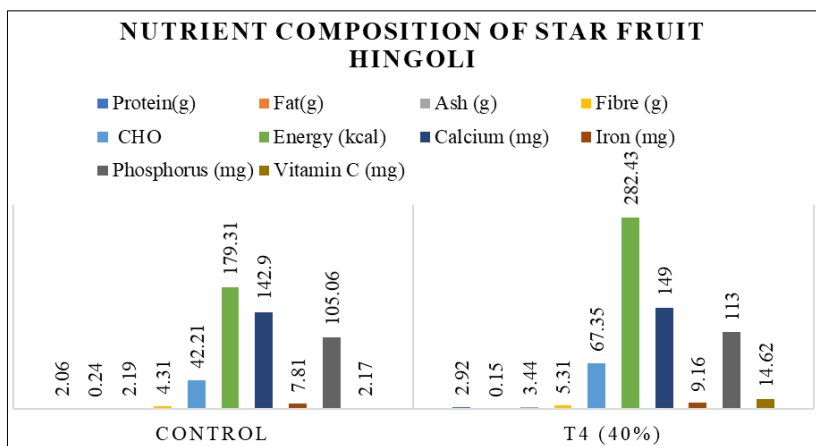


Fig 7: Nutrient composition of Hingoli



Plate 2: Star fruit powder added *Laddu* in different ratio

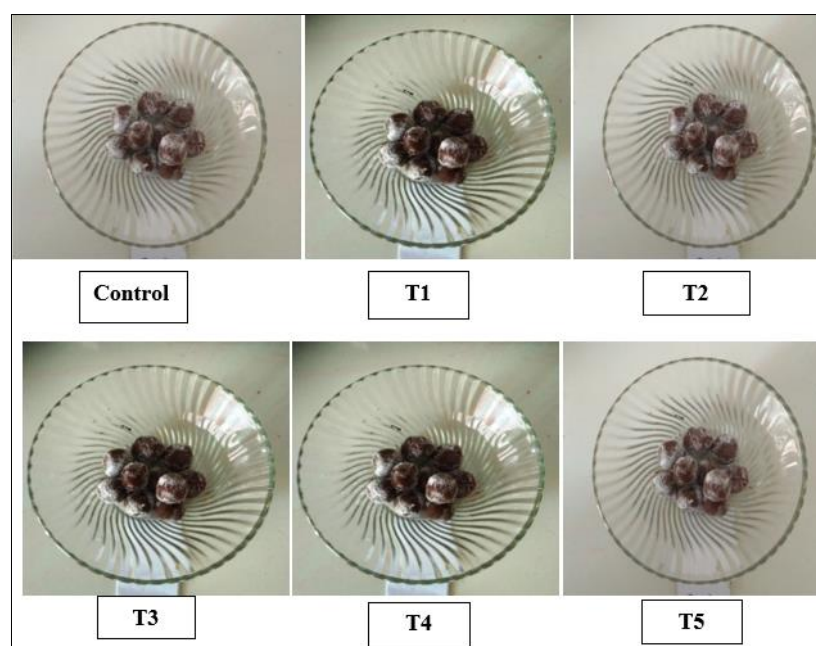


Plate 3: Star fruit powder added Hingoli in different ratio

Conclusions

The study discovered that digestive products made from star fruit powder met the necessary quality standards. After conducting nutritional and sensory analyses, the most successful combination was determined to be 40% star fruit powder and 60% wheat flour and tamarind powder. No significant differences were observed in the nutritional or sensory qualities of the other treatments.

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