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Formulation and Evaluation of Nutri Brittle Incorporating Sesame, Jaggery, Flaxseed, and Ragi Flour

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ABSTRACT

Traditional Indian sweets play a significant role in the country's dietary culture, with brittle (chikki) being one of the most widely consumed snacks. Conventionally prepared using jaggery and roasted nuts, it is enjoyed by all age groups and offers nutritional value. The present study aimed to develop a nutri brittle (nutrient-enriched chikki) by fortifying it with sesame seeds, jaggery, flaxseeds, and ragi flour to enhance both nutrition and consumer acceptability at an affordable cost. Four formulations were prepared: a control sample (T0: 100:0:0:0) and three experimental treatments — T1 (60:05:30:05), T2 (60:05:25:10), and T3 (60:05:20:15).

Physicochemical, microbial, and sensory evaluations were carried out for all samples. Among the formulations, T_1 (60:05:30:05) was found to be the most acceptable, showing a superior nutritional profile with carbohydrate (73.83%), protein (7.50%), fat (11.70%), ash (2.44%), and iron (5.83 mg). It also achieved the highest sensory scores, demonstrated microbial safety within permissible limits, and had low preparation cost.

The study concludes that nutri brittle enriched with sesame seeds, jaggery, flaxseeds, and ragi flour can serve as a nutritious, safe, and cost-effective product. Its high iron content makes it particularly beneficial for anemia patients and it can also contribute to addressing malnutrition, as defined by the world health organization (WHO)

Keywords Chikki; Nutri Brittle; Fortified brittle; Sesame; Jaggery; Flaxseed; Ragi flour; Nutritional evaluation; Sensory analysis; Functional food.

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1. . INTRODUCTION

India, with its diverse culinary traditions, has preserved a wide range of indigenous foods, particularly sweets. One of the most popular traditional snacks is **brittle (chikki)**, generally made with jaggery as the sweetening agent and roasted peanuts. A number of varieties of **brittle (chikki)** exist, with their names derived from the main ingredients used — such as puffed rice, roasted Bengal gram, sesame, and desiccated coconut (khobara). This sweet is widely consumed across both rural and urban South Asia, including India, Pakistan, Bangladesh, Nepal, and Sri Lanka. Some of the most renowned varieties originate from towns like **Lonavala, Matheran, Mahabaleshwar, Panchgani, Karjat (Maharashtra)** and **Bhuj (Gujarat)**.

India holds the **largest global share in sesame production and cultivation area**, with the crop being grown across multiple agro-ecological zones in different seasons (Bisht IS et al., 1998; Banerjee PP et al., 2009) [2,1]. Sesame is a valuable source of **calcium (~1%) and phosphorus (~0.7%)**, along with essential fatty acids such as **oleic (43%), linoleic (35%), palmitic (11%), and stearic acid (7%)**, which together account for nearly 96% of its total fatty acids (Saydut A et al., 2008). Owing to its distinct nutritional and therapeutic properties, sesame oil and seeds are widely utilized in food and health applications.

Jaggery (Gur), a traditional natural sweetener obtained by concentrating sugarcane juice, is popular worldwide under different local names (FAO, 2007) [6]. India is both the **largest producer and consumer**, contributing more than 70% of global jaggery production (Jagannadha Rao PVK et al., 2007) [7]. Jaggery is marketed in both solid block and semi-liquid forms. Known for its ability to provide instant energy and warmth, jaggery has cultural significance in India—for instance, serving water with jaggery*(gur)* to guests is a traditional practice. Beyond household consumption, jaggery is also used in

cattle feed, distilleries, medicine and Ayurveda formulations, and increasingly in confectionery products.

Flaxseed, recognized for its crisp texture, nutty flavor, and nutritional richness, is consumed either directly or incorporated into food products. It is a notable source of **high-quality protein, dietary fiber, and fat**, with soluble viscous fibers contributing to several health benefits (Kristensen et al., 2012) [9]. Its proximate composition typically includes **30–40% fat, 20–25% protein, 20–28% fiber, 4–8% moisture, and 3–4% ash**, while its oil is rich in **vitamins A, B, D, E, and minerals** (Coskuner & Karababa, 2007) [5]. The variation in nutrient content is mainly influenced by genotype and environmental conditions.

Finger millet (Ragi/Mandua), native to Ethiopia but extensively cultivated in India and Africa, is a significant staple food, especially among low-income populations (M.M. O'Kennedy et al., 2006) [10]. Nutritionally, finger millet is valued for its high levels of **calcium (0.38%), protein (6–13%), dietary fiber (18%), carbohydrates (65–75%), minerals (2.5–3.5%), phytates (0.48%), tannins (0.61%), and phenolic compounds (0.3–3%)**. Its nutraceutical potential lies in a variety of **health-promoting properties**, including anti-diabetic, anti-tumor, anti-diarrheal, anti-ulcer, anti-inflammatory, antioxidant, antimicrobial, and atherosclerogenic activities (Chethan S. & Malleshi N.G., 2007).

Table 1: Chemical composition of sesame seed, jaggery, flaxseed and Ragi (all values are expressed per 100g edible portion)

Constituents (%)	Sesame seed	Jaggery	Flaxseed	Ragi
Moisture	3.62	3.9	5.48	10.89
Protein	21.61	1.82	18.55	7.16
Fat	43.22	0.16	35.67	1.92
Ash	4.58	1.92	3.15	2.04
Carbohydrate	9.76	84.87	10.99	66.82
Iron (mg)	14.95	4.63	5.44	4.6

Source: Indian food composition tables, NIN (2017)

Justification:

In the present era, consumers are increasingly conscious about healthy eating habits, with special focus on reducing calorie intake while enhancing protein and dietary fiber consumption. Chronic health concerns such as diabetes, hypertension, and malnutrition are highly prevalent in India, and individuals suffering from these conditions require diets rich in protein and fiber but lower in calories. The development of fortified brittle (chikki) aims to provide a healthy, affordable snack prepared using nutrient-dense ingredients in an easily consumable form.

The formulation includes ragi flour, sesame seeds, flaxseeds, and jaggery—all recognized for their nutritional benefits. Ragi, sesame, and flax are excellent sources of calcium, while sesame also supplies copper, which plays a vital role in enzymatic and antioxidant activities. Flaxseed is heart-friendly due to its high content of omega-3 fatty acids. Jaggery contributes significantly by providing antioxidants and minerals like zinc, selenium, iron, and folate. These nutrients support immunity, reduce oxidative stress, and help maintain healthy hemoglobin levels, which is especially beneficial for women and individuals with anemia.

Since nearly 65% of the formulation is jaggery, the product offers an instant source of energy along with magnesium, which supports intestinal strength and contributes to daily mineral requirements. By combining these traditional, readily available ingredients, fortified brittle emerges as a nutrient-rich, low-cost food option. According to the World Health Organization, malnutrition refers to deficiency, excess, or imbalance in nutrient intake, and this product can help address such issues effectively.

Thus, fortified brittle (nutri chikki) provides a practical solution that is not only affordable for all economic groups but also contributes to improving health outcomes, particularly for anemia and malnutrition patients.

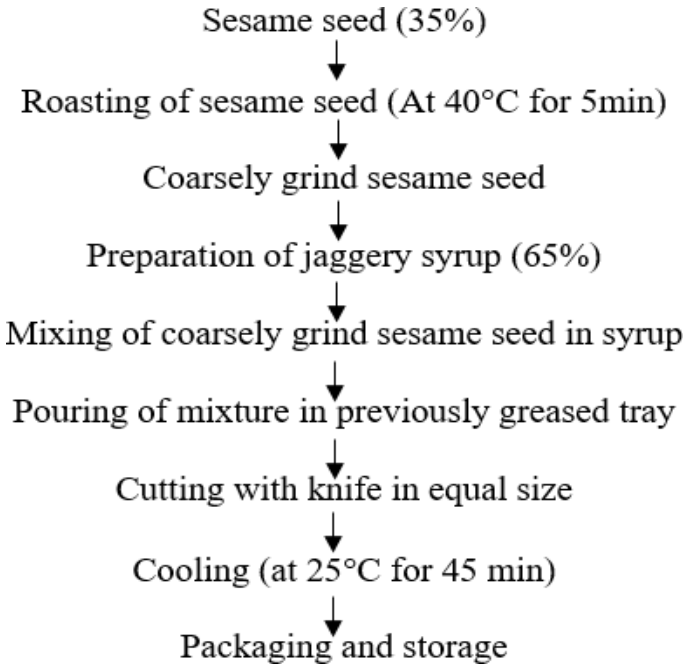
2. MATERIALS AND METHODS:

Fortified Brittle (chikki) manufacturing materials

The material and methods to be adopted during this investigation are given below:

1. Jaggery was collected from local market.

2. Sesame seed (til) was collected from local market.



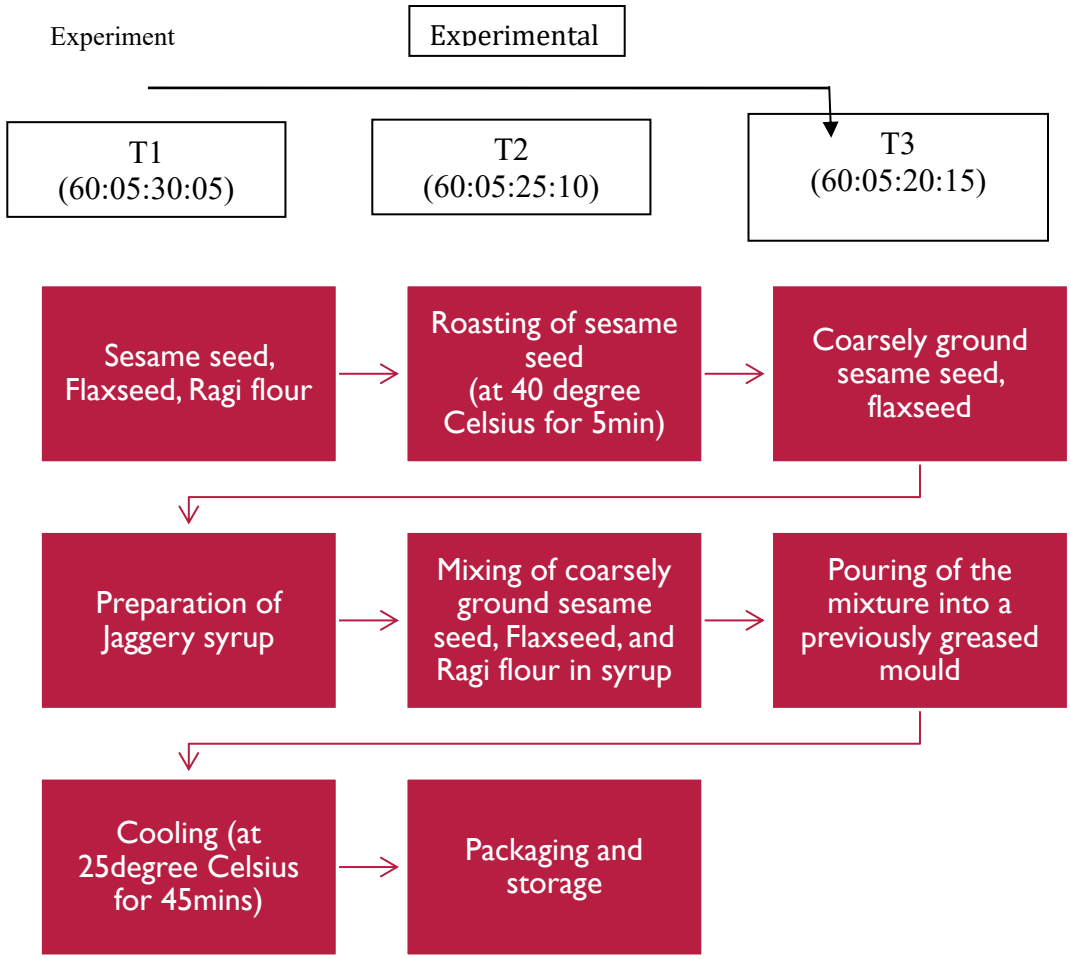
3. Flaxseed was collected from local market.

4. Ragi flour (nachani) was collected from local market

Flow diagram for the preparation of ragi flour

Flow diagram adopted for control sample: Control (T0)

Plan of Work:



Flow diagram for experimental sample

3. RESULTS AND DISCUSSION:

The data collected on different aspects were tabulated and analyzed statistically using the method of analysis of variance and critical difference technique. The significant and nonsignificant differences observed have been analyzed critically within and between the treatment combinations.

Table 2: Average data for different parameter of control and experimental fortified brittle (chikki)

Parameter	Treatment			
	T_0	T_1	T_2	T_3
Physico-chemical analysis (in present)				
Moisture	3.80	4.53	4.80	5.00
Fat	15.32	11.70	9.96	8.30
Protein	8.80	7.50	6.90	6.30
Carbohydrate	69.22	73.83	76.02	78.07
Ash	2.86	2.44	2.32	2.33

Total solid	96.20	95.47	95.2	94.98
Mineral analysis				
Iron	8.25	5.83	5.77	5.73
Microbiological analysis				
Yeast and mold count (cfu/gm)	12.40	6.80	8.00	9.20
Coliform count	Nil	Nil	Nil	Nil
Organoleptic score (9-point hedoni cscale)				
Color and appearance	8.90	8.30	8.10	7.40
Body and texture	8.60	8.00	7.20	6.70
Flavor and taste	8.80	8.40	8.10	7.60
Overall acceptability	8.74	8.12	8.74	7.20
Cost analysis				
Cost in Rs./100 gm	8.33	6.34	6.35	6.36

Figure 1.

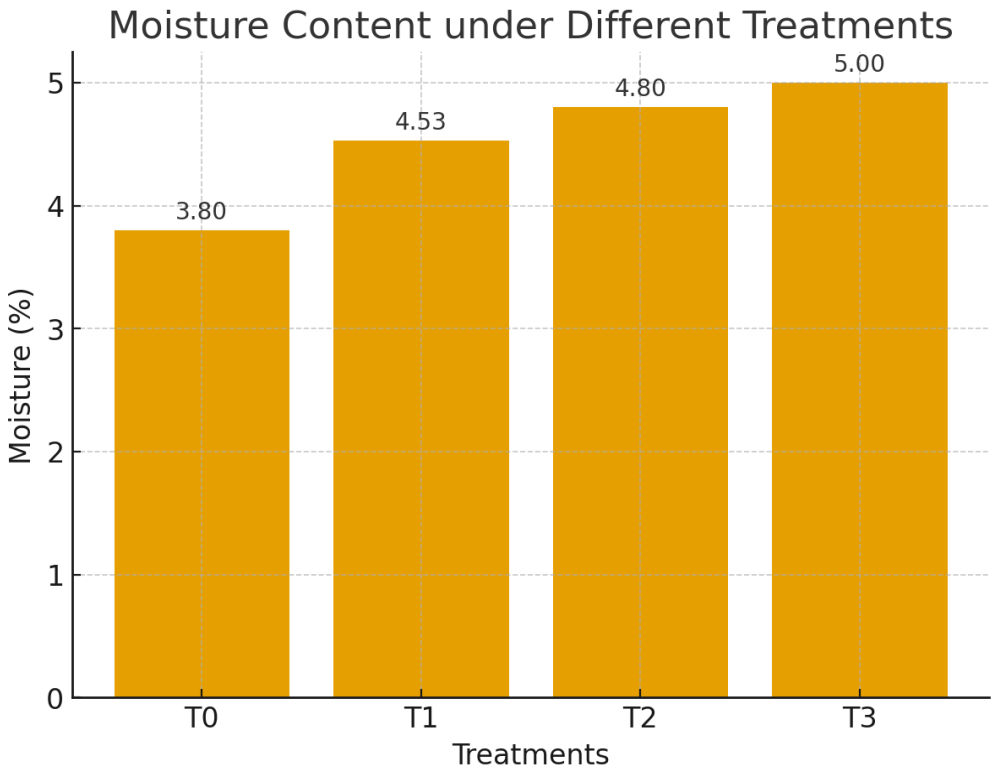


Figure 2

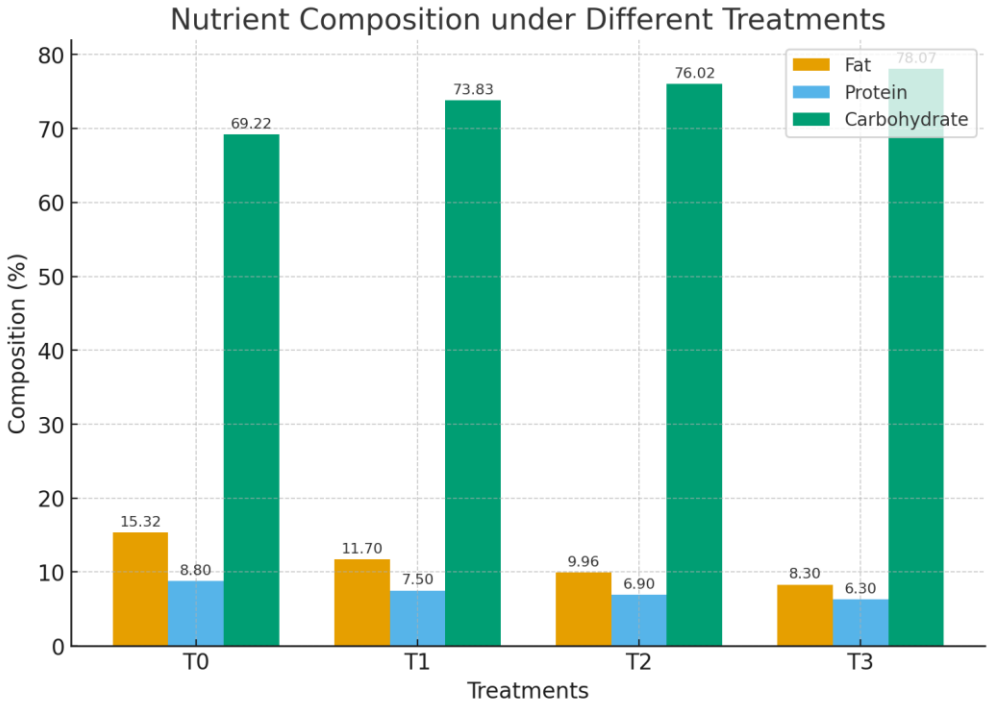
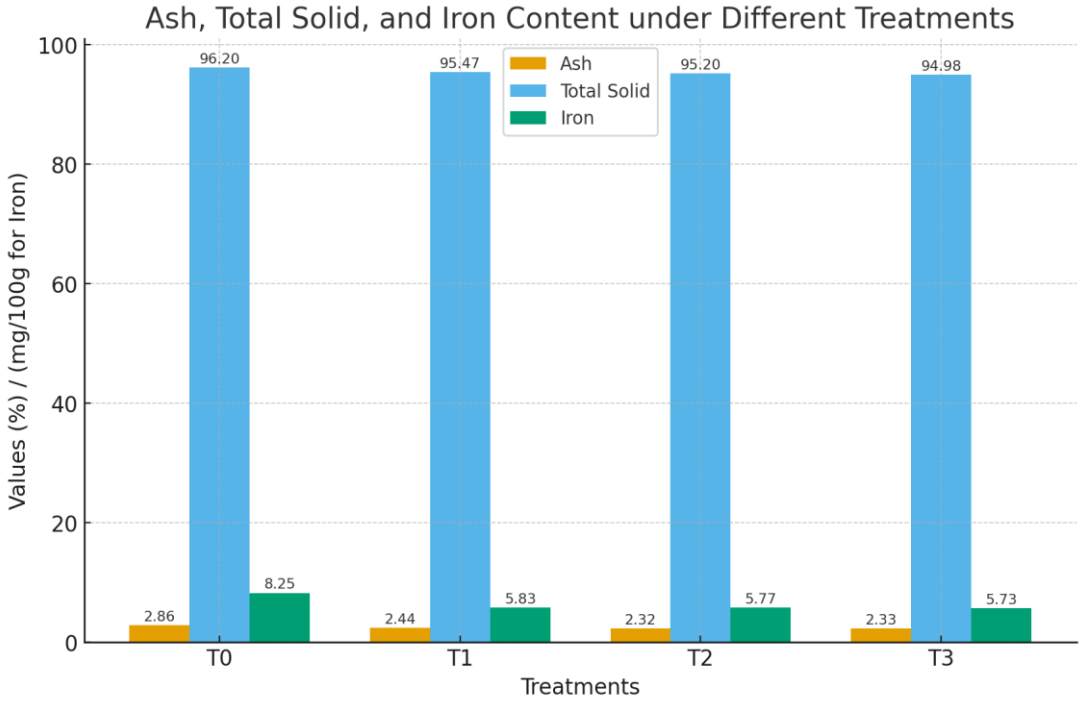


Figure. 3



4. SUMMARY AND CONCLUSION:

Physico-Chemical Analysis Moisture Percentage There was significant difference in moisture content of different treatment combination. Maximum moisture percent was recorded in the sample of T3 (5.00) followed by T2 (4.80), T1 (4.53) and T0 (3.80). The difference in moisture was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments. Fat Percentage There was significant difference in fat content of different treatment combination. Maximum fat percent was recorded in the sample of T0 (15.32) followed by T1 (11.70), T2 (9.96) and T3 (8.30). The difference in fat was due to the difference in composition of sesame seed,

jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments. Protein Percentage There was significant difference in protein content of different treatment combination. Maximum protein percent was recorded in the sample of T0 (8.80) followed by T1 (7.50), T2 (6.90) and T3 (6.30). The difference in protein was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments. Carbohydrate Percentage There was significant difference in carbohydrate content of different treatment combination. Maximum carbohydrate percent was recorded in the sample of T3 (78.02) followed by T2 (76.01), T1 (73.83) and T0 (69.22). The difference in carbohydrate was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. which are used in different proportions in different treatments. Ash Percentage There was significant difference in ash content of different treatment combination. Maximum ash percent was recorded in the sample of T0 (2.86) followed by T1 (2.44), T2 (2.32) and T3 (2.33).The difference in ash was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments. Total Solid (Ts) Percentage There was significant difference in TS content of different treatment combination. Maximum TS percent was recorded in the sample of T0 (96.20) followed by T1 (95.47), T2 (95.20) and T3 (94.98). The difference in TS was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. which are used in different proportions in different treatments. Iron Percentage There was significant difference in iron content of different treatment combination. Maximum iron percent was recorded in the sample of T0 (8.25) followed by T1 (5.83), T2 (5.77) and T3 (5.73). The difference in iron was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments?

Microbiological Analysis:

Yeast and Mould Count

There was significant difference in yeast and mould count of different treatment combination. Maximum yeast and mould count was recorded in the sample of T0 (12.40) followed by T3 (9.20), T2 (8.00) and T3 (6.80).

Coliform Count:

Coliform count was study for addition of different samples of flaxseed and ragi flour based fortified brittle (chikki). The colifrom count showed negative result assuring hygienic production of the product.

Organoleptic Analysis

Color and Appearance Score

There was significant difference in color and appearance score of different treatment combination. Maximum color and appearance score was recorded in the sample of T0 (8.90) followed by T1 (8.30), T2 (8.10) and T3 (7.40). The difference in color and appearance was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments.

Body and Texture Score

There was significant difference in body and texture score of different treatment combination. Maximum body and texture score was recorded in the sample of T0 (8.60) followed by T1 (8.00), T2 (7.20) and T3 (6.70). The difference in body and texture was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments .

Flavor and Taste Score

There was significant difference in flavor and taste score of different treatment combination. Maximum flavor and taste score was recorded in the sample of T0 (8.80) followed by T1 (8.40), T2 (8.10) and T3 (7.60). The difference in flavor and taste was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments.

Overall Acceptability Score

There was significant difference in overall acceptability score of different treatment combination. Maximum flavor and taste score was recorded in the sample of T0 (8.74) followed by T1 (8.12), T2 (7.74) and T3 (7.20). The difference in overall acceptability was due to the difference in composition of sesame seed, jaggery and flaxseed and ragi flour. Which are used in different proportions in different treatments.

Cost Analysis

The cost price of flaxseed and ragi flour based fortified brittle (chikki) sample were less than the Market price of brittle (MRP 15Rs. /100gm). The highest cost price was found in sample T0 (8.33 Rs. /100gm) Followed by T3 (6.36 Rs. /100gm), T2 (6.35 Rs. /100gm) and T1 (6.34 Rs. /100gm).

5. CONCLUSION:

Sesame seed, jaggery, flaxseed, and ragi flour were used in this study because a possible synergistic relationship is thought to exist between these ingredients. They protect against many same diseases and their health benefits may be increased when they are together in the food products. The use of ragi flour and flaxseed gave the low cost but nutritious product. The results obtained from the statistical analysis concluded that a noval product fortified with sesame seed, jaggery, flaxseed, and ragi flour was successfully produced fortified brittle (chikki). After the optimization of various ingredients, the treatment T1 (65:10:20:05) was found to be most favorable because of higher nutrition profile as well as it scored maximum for all sensory appeal, microbial count within the permissible limit. It fulfills the 40% iron intake of males and females (According to Recommended Dietary Allowance (RDA) intake of the iron/day) and also its preparation cost is low.

Hence it can be concluded that the brittle that was prepared/ created in this study fallow under high carbohydrate, high protein but low-cost food and acceptable nutty flavor that would be an appeal to consumers following these in their diets as a fortified food product..

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