

Formulation and standardization of millet-based protein-mineral enriched granola bar

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ABSTRACT

Malnutrition predominantly affects children and women, presenting itself in various forms such as undernutrition (characterized by wasting, stunting, and being underweight), insufficiency of vital vitamins or minerals, obesity, and leading the development of non-communicable diseases linked to dietary factors. Overcoming malnutrition can be achieved through the scientific preparation of traditional foods incorporating millets and pulses in appropriate quantities, considering the existing knowledge and preparation gap in traditional millet-based foods across generations. Recognizing this, NITI Aayog has recently unveiled a pilot program aimed at integrating millets into the Integrated Child Development Services (ICDS) and Mid-Day Meal (MDM) schemes nationwide.. The present study was undertaken to develop a protein and mineral-enriched granola bar based on millets mainly a combination of bajra, jawar, ragi crispy, amaranth puff, and moong dal. From a sweetness and health point of view, jaggery was used instead of refined sugar. The ingredients were mixed in different proportions based on response surface methodology (RSM) and the granola bars were prepared using a hot pressing technique. The optimized formulation was selected using RSM based on the protein content, overall acceptability, bowl life, and hardness. Further evaluation studies like nutrient composition and shelf life were carried out by standard analytical methods. The moisture content found to be 3.26%, while protein 10.85gm/100 gm, fat 11.80gm/100gm, carbohydrate 69.65gm/100gm, crude fibre 1.88mg/100gm. The total ash content of the bar was 2.65g/100g. The calcium and iron content on analysis was found to be 88.20mg and 5.03 mg/100gm respectively. The developed bar provided 428.20 kcal of energy per 100g, which qualified the product as a good energy-dense snack

for children and women whom ed are o undernutrition. The microbial load of this bar was

found to be below detectable limits during storage for 2 months. The unit cost of preparation of the granola bar was Rs.6.00/- per 25g. The developed millet-based granola bar is found to be a nutritious snack, easy to prepare, affordable, and more cost-effective than the commercial granola bar.

Keywords

Malnutrition, RSM, millets, overall acceptability

1. INTRODUCTION

A serious public health issue concerning malnutrition among children under five in India has been acknowledged. India has been identified to have one of the highest rates of underweight children globally, with a rate that is almost double that of Sub-Saharan Africa. This issue's concentration in India is evident through the observation that a significant burden is primarily borne by only five states and 50% of villages, equating to about 80% of the problem. The global impact of malnutrition is believed to result in approximately 2.3 million infant deaths annually, which accounts for 41% of all infant mortality in developing nations. (Swoop et al., 2017).

Finger millet, also known as ragi or manual (*Eleusine coracana* L.), is a widely cultivated crop in India and worldwide. India holds the title of being the largest producer, accounting for approximately 60% of the global output. Unlike other grains, finger millet is consumed without hulling. It has a growth period of 100 to 130 days and is well-suited for acidic soils and regions with higher rainfall (600 to 1,200 mm). In terms of nutritional composition, finger millet grain contains 81.5% carbohydrates, 9.8% protein, 4.3% crude fiber, and 2.7% minerals. Notably, its crude fiber and mineral content surpass those of rice, wheat, and other millets, while its protein content is also significant. (Amir et al., 2014)

Sorghum [*Sorghum bicolor* (L.) Moench], a staple crop originating from Africa, continues to play a

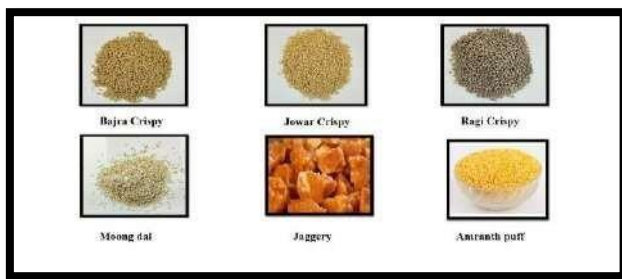
crucial role in the diets of rural populations. With an annual production of between 100,000 and 180,000 tonnes and grown primarily in arid regions with an average temperature of 25°C, sorghum serves as a source of food in areas with limited resources. The grain, with a protein content ranging from 8-12%, a starch content of 65-76%, and 2% fiber, is comparable in composition to maize except for its lower oil content. The germ of sorghum, however, stands out as a nutritious source of protein (19%), ash (10%), and oil (28% of the germ). (Abah et al., 2020).

Pearl millet (*Pennisetum glaucum*), commonly known as Bajra, Bajri, Sajje, Kambu, Kamban, and Sajjalu in various regions of India, belongs to the Poaceae family. This cereal crop plays a versatile role in providing sustenance, forage, and food. In comparison to other cereals like wheat, rice, maize, and sorghum, pearl millet exhibits exceptional nutritional value, attributed to its deep root system, which enables it to access nutrients from the soil. It is a rich source of vital minerals such as iron, zinc, magnesium, copper, manganese, potassium, and phosphorus. Consequently, pearl millet provides ample energy with a calorific value of 361 Kcal per 100g, and it possesses a high fiber content of 1.2g per 100g. These findings are highlighted in a study conducted by Monika et al. in 2020.

2. Material and methodology

2.1 Raw Materials

Formulations for the granola bar food composed of amaranth, jaggery, and moong dal procured from the local market of Loni kalbhor. Finger millet crispy, pearl millet crispy, and sorghum crispy were procured from Susy foods, Dadar West Mumbai. Amaranth and moong dal were procured in one lot and stored in closed containers for further use in the experiment.



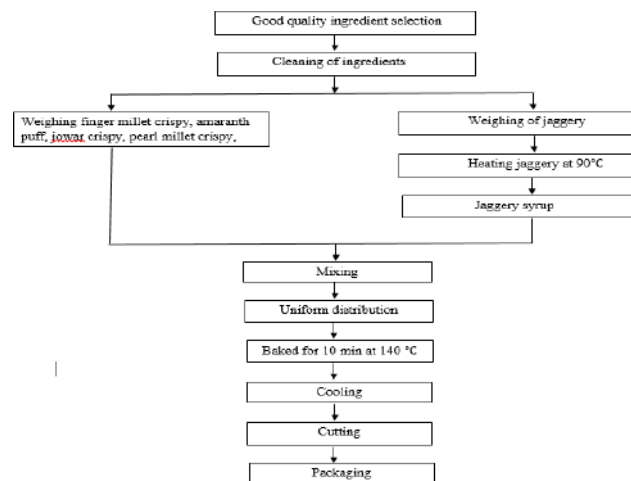
2.2 Preliminary trials

Table No-1

Raw material	S1	S2	S3
Ragi crispy	2.5	5	10
Amaranth puff	2.5	5	10
Jowar crispy	2.5	5	10
Bajra crispy	2.5	5	10
Moong dal	25	5	10
Jaggery	65	75	50

2.3 Procedure for developing granola bar

The granola bar development procedure reported by Fast and Caldwell (1990) was adopted for producing the granola bar. Various types of millets crispies are used (finger millet crispy, pearl millet crispy, and sorghum crispy) other ingredients namely amaranth puff, and fired moong dal. All these crispies are purchased from Susy food Pvt limited and checked for its purity before being used in the granola bar development. Following this method, twenty different formulations of granola bars in triplicate varying finger millet crispy, pearl millet crispy, and moong dal concentrations were developed.



3. Results and discussion

3.1 Analysis of Raw Material

3.1.1 Proximate composition

A proximate composition such as moisture, ash, protein, crude fiber, carbohydrate, and fat analyzed for the selected raw material was discussed below.

Table 1 Proximate composition

Raw Materials	Moisture	Fat	Protein	Ash	Crude fiber	Carbohydrate
Bajra crispy	4.16 ± 0.76	1.64 ± 0.06	9.43 ± 0.60	1.78 ± 0.25	2.10 ± 0.36	80.89 ± 1.10
Jowar crispy	4.31 ± 0.65	1.35 ± 0.05	9.23 ± 0.92	2.38 ± 0.53	3.85 ± 0.78	78.88 ± 1.11
Ragi crispy	5.44 ± 0.60	2.36 ± 0.06	8.50 ± 1.32	1.95 ± 0.50	4.71 ± 0.25	77.04 ± 1.05
Amranth puff	4.93 ± 0.25	3.59 ± 0.18	9.25 ± 0.66	1.70 ± 0.32	5.03 ± 0.45	75.50 ± 1.10
Jaggery	6.83 ± 0.76	1.25 ± 0.25	2.50 ± 0.50	4.50 ± 0.50	1.13 ± 0.12	83.79 ± 0.20
Moong dal	7.10 ± 0.36	1.45 ± 0.40	11.33 ± 1.52	3.50 ± 0.50	3.41 ± 0.38	73.21 ± 1.09

3.2. Physico-chemical and sensory evaluation of granola bar

3.2.1. Chemical analysis of granola bar

Table 2 Physicochemical analysis of granola

Parameter	Sample 17
Moisture %	3.26 ± 1.00
Protein %	10.85 ± 1.05
Fat %	11.8 ± 0.99
Carbohydrate %	69.56 ± 1.00
Energy Kcal/100g	428.2 ± 0.90
Total ash on a dry basis %	2.65 ± 1.01
Crude fibre %	1.88 ± 0.83

3.3. Effect of storage period on the moisture content of granola bar

3.3.1. Microbial quality of granola bar during storage period

The study measured the total plate count and yeast/mold count of the granola bars during a 60-day storage period. The results indicate that the use of high-density polyethylene (HDPE) and low-density polyethylene (LDPE) as packaging materials prevented microbial growth in the granola bars during the 60-day storage period.

Table 3 Microbial quality of granola bar during storage period

Storage period	HDPE	LDPE
0	3.26 ± 0.04	3.26 ± 0.04
10	3.30 ± 0.05	3.34 ± 0.04
20	3.35 ± 0.05	3.40 ± 0.06
30	3.42 ± 0.02	3.44 ± 0.04
40	3.51 ± 0.03	3.54 ± 0.06
50	3.57 ± 0.02	3.61 ± 0.03
60	3.67 ± 0.02	3.70 ± 0.08

4. Conclusion:

The formulation and standardization of a millet based protein-mineral enriched granola bar made from pearl millet, sorghum, ragi crispy, amaranth puff, jaggery, and moong dal can be an effective solution to address malnutrition. The addition of amaranth puff adds a crispy texture to the granola bar, which can provide a satisfying and enjoyable eating experience, encouraging individuals to

consume the supplement regularly. It is evident that the developed millet based granola bar is found to be nutritious snack, easy to prepare, affordable, and more cost effective than the commercial granola bar.

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