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Formulation, development and sensory acceptability of high calorie snack bars

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ABSTRACT

Background: The demand for consumption of healthy, innovative, processed and convenience foods are increasing rapidly due to increasing in awareness about health and lack of time to cook has led to the development of cereal bars. Study focused on developing high calorie snack bars to be used as a complementary food for malnutrition. Objectives: To develop high calorie millet-based snack bar as a complementary food for malnutrition. Materials and methods: Snack bars were made with millets, nuts and oil seeds, sweeteners and gum. The optimized composite mix formulation was enriched with inulin. The developed bars were evaluated for sensory acceptability using 9-point hedonic scale. Physical characteristics and nutrient content were estimated. Results: The high calorie bar was prepared with locally available ingredients. The sensorial attributes of bars made with jaggery scored higher in comparison with other sweeteners. The developed bars had calorific value of 402-430 kcal/100gm with protein content in the range of 11%, fat 13-14%, fibre 2-3% and carbohydrates 57- 64%. Calcium content ranged from 44.1 -70.9 mg, iron 2-3mg, whereas zinc 50.41mg and magnesium 2.04mg/100g was constant in all samples. Conclusion: Incorporation of millets enhanced the functional and nutrient content of snack bars and could be used as a functional ingredient for better health.

Keywords— *Malnutrition, high calorie bar, millets, physico-chemical properties, sensory evaluation*

1. INTRODUCTION

Malnutrition is defined by World Health Organization as "the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance and specific functions" (Batool *et al.*, 2015). Various approaches like dietary enhancement, improvement in blended fortified foods, modification of ready-to-use therapeutic foods (RUTFs) and application of food supplements which are complementary are the widely used strategies to improve the diet of malnourished children (de Pee & Bloem, 2009). The salient characteristic feature of diet needs to prevent and treat malnutrition emphasise on higher demand for micronutrients, energy density, high and adequate protein quality, low levels of anti-nutrients, adequate amount of fat content in terms of quantity and quality. Other features include acceptable taste and texture, cultural acceptability, ease in preparation, affordability and a low risk of contamination. Complementary food supplements are food-based complements that improve nutritional value of the diet that can be added in preparation or used in addition to regular diet. However, amount of energy consumed in a day does not affect the dosage level of complementary foods (Nestel *et al.*, 2003).

Energy bars are the supplement bars, which provide high-energy foods for all age groups who require quick energy but do not have time for a meal. A typical energy bar of 100 grams will likely to supply 300-400 Kcal, 10-18 grams of fat and 30-55 grams of carbohydrates (Nutrition comparison chart, 2010). Energy bars or high calorie bars with adequate protein and fat can be used as a supplementary or complementary food. These bars are mostly consumed by people who want to maintain calorific needs (Norajit *et al.*, 2011). High calorie bars are mostly made up of nuts and oil seeds, whole grains, dehydrated fruits etc., in a mutual combination that results in appropriate physical parameters as well as sensorial attributes (Esteller *et al.*, 2004).

2. MATERIALS AND METHODS

Formulation

The major ingredients used in the study were millets, corn syrup, honey, jaggery, nuts, oilseeds and gums. The millets, nuts and oilseeds were selected based on their nutrient profile to provide high energy and functional properties. Various formulations were developed by altering the binding ingredients and its percentage in developed products.

Procurement of the ingredients

Millets (proso, foxtail, Italian, pearl), groundnut, sunflower seeds, jaggery and honey was purchased from local market in Anantapur. Corn syrup was bought from Bangalore and xanthan gum from Sattvic foods. The ingredients were stored at room temperature before use.

Manufacturing of high calorie nutri-bars

The millets, nuts and oilseeds were roasted at 120℃ for 5 minutes. The binder solution was prepared using corn syrup, honey and jaggery at different proportions and brix of the solution was maintained between 80 and 85. The process is given in the form of flow chart (Fig 1).

Computational analysis

Computation of various nutrients for the developed bars was determined using 'Diet Soft' software. This software provides nutritional information of foods as given in Indian food composition table (Longvah *et al*., 2017). The analysis was used to compute the proximate nutrients and several other minor and major nutrients.

Table 1: Development of high calorie snack bar with millets (40%):

Ingredients	HB1	HB2	HB3	HB4	HB5	HB6	HB7	HB8	HB9	HB10
Millets	40	40	40	40	40	40	40	40	40	40
Nuts and oil seeds	29	29	29	29	29	30	30	30	30	30
Binder	30	30	30	30	30	30	30	30	30	30
Xanthan gum	1	1	1	1	1	-	-	-	-	-

*HB1- High Calorie bar (Honey and Corn syrup - 1:2); HB2- High Calorie bar (Honey and Jaggery – 1:2);HB3- High Calorie bar with only honey; HB4- High Calorie bar with only Corn syrup; HB5- High Calorie bar with only jaggery; HB6 - High Calorie bar (Honey and Corn syrup - 1:2 without gum); HB7- High Calorie bar (Honey and Jaggery - 1:2 without gum); HB8- High Calorie bar (honey without gum); HB9- High Calorie bar (Corn syrup without gum); HB10- High Calorie bar (Jaggery without gum).

Bulk density

The bulk density of the developed samples was calculated using the formula given by Ranganna (1986). Weighed sample (10 g) was added into 50 ml measuring cylinder and the initial weight was noted. The sample was tapped using bulk density apparatus till constant final volume was obtained. Calculation:

$$\textbf{Loose Bulk density (LBD)}\left(\frac{\textbf{g}}{\textbf{ml}}\right) = \frac{\textbf{weight of sample}}{\textbf{initial volume}}$$

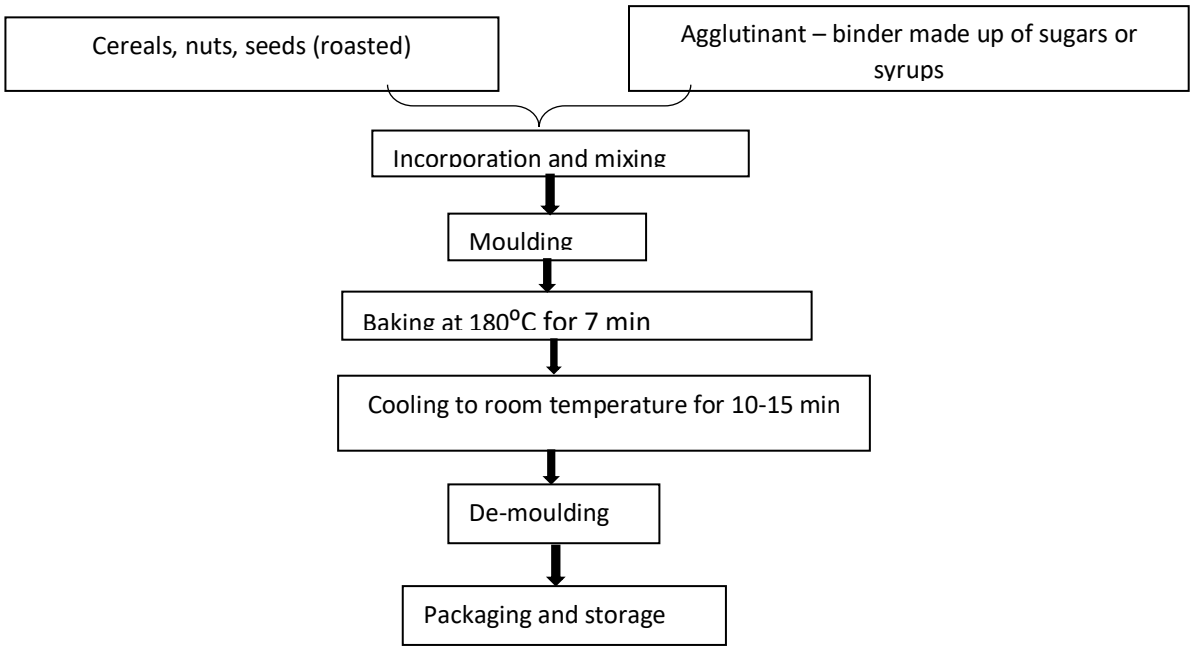

Fig. 1: Processing of high calorie bar

Water activity

Availability of free water in samples was measured by Digital Lab master water activity meter (Novasina).

pH

pH was determined using the method given by Berwal *et al* (2004). The sample was weighed (5g) macerated with 50 ml of water, allowed to stand for 30 minutes and supernatant was decanted. The pH meter was calibrated with standard buffer solution to determine the pH of the supernatant.

Browning index

According to the method given by Ranganna, the browning index was determined, (1986). 5 ml of 60% alcohol was added to 0.5 g of macerated sample and kept overnight. The contents were filtered and colour intensity was read at 440 nm using 60% alcohol as blank.

Browning index = OD of sample - OD of blank.

Colour

The colour of the sample was measured for Hunter L*, a*, b* units, where L* denote brightness/ luminosity, a* indicate redness (+)/greenness (-), b* for yellowness (+)/blueness (-) using Konica MINOLTA (R-10) colour reader. The obtained values for L*, a* and b* data were transformed to colour index

$$\mathbf{CI = 1000 \times a^*/ L^* \times b^*}$$

Width and length

Using Vernier callipers (0.01mm accuracy), total width of the nutrition bars that were placed at edge to edge was measured. Mean value is taken as average width of the nutrition bars (Siddiqui *et al*., 2003). Similarly, the length was also measured and the mean value is determined as average length.

Weight

Using digital weighing balance, the weight of the nutrition bars was obtained and the mean was calculated.

Thickness

Nutrition bars were placed one above the other and the thickness was determined using a ruler in millimetre. The average value ids obtained by measuring thrice and was reported in centimetre (AACC, 2000).

Spread ratio

According to the method given by Akubor and Ukwuru (2003), spread ratio is determined by subtracting width of the nutrition bars by thickness.

$$\mathbf{Spread\ ratio = W/T}$$

where, W-width of the nutrition bar; T- thickness of the nutrition bar

Volume

Using length (L), thickness (T) and width (W) of the nutrition bars, volume is determined.

$$\mathbf{Volume\ (cm^3) = L \times W \times T}$$

Density

According to Srivatsava *et al*., (2012), density was obtained by calculating the ratio between weight and volume.

$$\mathbf{Density\ (g/cm^3) = weight\ in\ grams\ /\ volume\ in\ cm^3}$$

Sensory acceptability

The products were assessed for their sensory characteristics with the help of semi- trained panellists using 9-point hedonic scales. The results were analysed using SPSS software.

3. RESULTS AND DISCUSSION

Computational analysis

The computed values of proximate composition for different formulation is given in table 2. The calorific value ranged between 402.57 and 430.15 kcal/100 g of the sample. The protein and fat content were found to be 11.56 to 11.85 g and 13.62 to 14.17 g/ 100g respectively. The carbohydrate content was found to be 57.85 to 64.49 g/100g respectively. Products had a range of 2-3 g/100g of fibre. A large variation in the calcium content was found among the samples, whereas zinc and magnesium content did not vary among the samples. Formulations that had jaggery as one of the ingredients showed higher amount of iron content in comparison to other samples.

Table 2. Nutritive value (per 100 gm) of high calorie snack bar with millets (40%)

Samples	Energy [kcal]	Fat [g]	Protein [g]	Carbs [g]	Crude fibre[g]	Fe [mg]	Ca [mg]	Zn [mg]	Mg [mg]
HB1	418.77	13.62	11.56	62.44	3.38	2.99	44.60	2.04	50.40
HB2	415.37	13.64	11.64	61.44	3.38	3.51	60.60	2.04	50.40
HB3	402.57	13.62	11.62	58.34	3.38	3.13	45.6	2.04	50.4
HB4	426.87	13.62	11.53	64.49	3.38	2.92	44.10	2.04	50.40
HB5	421.77	13.65	11.65	62.99	3.38	3.71	68.10	2.04	50.40
HB6	422.05	14.14	11.76	61.95	2.73	3.04	47.40	2.04	50.40
HB7	418.65	14.16	11.84	60.95	2.73	3.56	63.40	2.04	50.40
HB8	405.85	14.14	11.82	57.85	2.73	3.18	48.40	2.04	50.40
HB9	430.15	14.14	11.73	64.00	2.73	2.97	46.90	2.04	50.40
HB10	425.05	14.17	11.85	62.50	2.73	3.76	70.90	2.04	50.40

Physicochemical parameters

The length and width of the developed cereal bars were found to be 8±0.5cm and 4±0.5cm respectively. The thickness was in the range of 21-27 mm. Yadav and Bhatnagar (2017) conducted a study on the effect of supplementation on cereal bars reported the length of bars of about 9±0.5cm and a difference in width of bar with legume supplementation. The width of the control cereal bar

was similar to the present study. The spread ratio was constant for all the products with a deviation of ±0.05 and similar result was reported by Yadav and Bhatnagar (2017).

Water activity

The ratio of water vapor pressure of food product to vapor pressure of pure water at similar temperature indicates water activity.

Availability of free water is the water activity of the product, expressed as percentage of equilibrium of microbial growth in developed products. Free water available in product was considered as a criterion for microbial growth. Therefore, low level of free water available would retard the growth of microbes in the product. Garcia *et al*., (2012) reported the water activity in the range of 0.29 and 0.37, which was significantly different ($p < 0.05$) for cereal bars prepared with roasted rice bran ranged from 0.59-0.61, was comparatively higher than the current study. Dar *et al.*, (2006) studied the effect of bran on certain properties of snack foods and reported the water activity in the range of 0.39-0.47, which was similar to current study.

Browning index

Browning is a chemical process, influenced by various factors as temperature, moisture, air etc (Muralikrishna *et al.*, 1969). Browning index is defined as brown colour purity, the most common indicators observed in sugar containing food products (Buera *et al.*, 1986). The browning index of the developed products were found to be 0.12 to 0.37. Padmashree *et al.*, (2018) studied the physio-chemical properties of choco quinoa nutribar and reported browning index of 0.231 in the developed product, which was in accordance with current study.

Colour

The L*, a* and b* values of developed samples are given in the table 4. The values of L*, a* and b* ranged from 46.97- 53.43, 5.37-7.5 and 10.73- 14.07 respectively. A study on low-calorie cereal bar (Su-Ah *et al.*, 2017) reported L*, a* and b* values of 45.69, 6.34 and 19.92 respectively. Giri and Mridula (2016) conducted a study on energy bars with potato extrudates which determined L*, a* and b* values in the range between 33.62-59.35, 5.11-7.45 and 8.87-16.62 respectively.

Table 3. Physico-chemical analysis of developed high-calorie bar

Parameters	HB 1	HB2	HB3	HB4	HB5	HB6	HB7	HB8	HB9	HB10
a_w	0.37±0.01	0.36±0.02	0.31±0.00	0.33±0.00	0.29±0.00	0.33±0.01	0.31±0.00	0.30±0.00	0.34±0.00	0.32±0.00
pH	6.65±0.03	6.76±0.03	6.57±0.01	6.54±0.10	6.66±0.03	6.52±0.05	6.65±0.01	6.61±0.01	6.62±0.01	6.63±0.02
WAI	8.18±0.24	8.02±0.08	8.11±0.10	8.41±0.14	8.06±0.05	7.98±0.08	7.94±0.05	8.60±1.16	7.93±0.04	7.58±0.15
WAC	8.25±0.16	8.08±0.08	8.18±0.10	8.79±0.61	8.12±0.04	8.13±0.03	8.07±0.05	8.11±0.07	8.00±0.06	8.25±0.16
BD	2.03±0.12	2.17±0.12	2.53±0.12	2.10±0.10	2.27±0.21	2.00±0.00	2.03±0.06	1.93±0.06	1.97±0.06	2.00±0.00
BI	0.37±0.46	0.19±0.01	0.21±0.03	0.22±0.02	0.26±0.01	0.29±0.01	0.26±0.01	0.12±0.01	0.25±0.01	0.24±0.00
Length (mm)	80.36±0.25	80.34±0.61	83.41±2.24	85.12±0.77	81.36±1.99	84.11±0.76	80.45±0.95	88.36±0.55	87.19±2.07	86.44±0.15
Width (mm)	43.83±0.05	41.51±0.20	43.55±0.29	44.64±0.14	42.12±0.08	43.55±0.25	41.56±0.31	42.86±0.32	43.55±0.14	40.89±0.46
Thickness (mm)	27.63±0.39	23.26±0.45	28.41±0.43	28.62±0.38	24.22±1.56	26.66±0.21	24.25±0.15	26.12±0.42	26.53±0.28	21.71±0.22
Volume (cm^3)	97.31±0.97	77.57±2.45	103.19±3.64	108.74±2.73	83.10±7.39	97.65±1.09	81.07±0.86	98.92±2.92	100.72±1.00	76.73±1.50
Density (g/cm^3)	0.90±0.03	1.31±0.05	0.85±0.01	0.76±0.03	1.13±0.07	0.94±0.05	1.16±0.11	0.92±0.03	0.85±0.02	1.43±0.10
Spread ratio	1.59±0.02	1.79±0.03	1.53±0.03	1.56±0.02	1.74±0.11	1.63±0.02	1.71±0.02	1.64±0.01	1.64±0.01	1.88±0.00

Sensory evaluation

9-point hedonic scale was used to study the sensorial acceptability of the developed product in terms of organoleptic parameters: colour, appearance, taste, flavour, mouthfeel and overall acceptability. The overall acceptability of the product ranged from 6 to7 (fig 2.). The texture was little harder and grainy. The study further revealed that taste of developed products depended upon the binder used.

Table 4. Colour parameters of the developed high calorie bar

Parameter	HB 1	HB2	HB3	HB4	HB5	HB6	HB7	HB8	HB9	HB10
L	53.43±0.25	51.30±1.20	48.50±1.15	48.47±0.91	51.50±1.35	52.97±1.07	46.97±1.86	52.40±1.23	50.60±1.48	50.33±0.59
A	5.27±0.35	5.80±0.50	7.53±0.45	5.57±0.55	5.37±0.81	7.50±0.85	5.67±0.76	5.43±0.47	5.90±0.70	6.53±0.57
B	12.70±0.36	11.80±1.60	13.23±1.10	11.23±1.12	13.70±1.74	14.07±0.06	10.73±1.10	12.13±0.72	11.93±0.47	13.13±0.35
c	13.77±0.15	13.13±1.65	15.23±0.75	12.37±1.42	14.13±0.42	15.97±0.40	12.13±1.17	13.30±0.62	13.40±0.26	14.70±0.36

h	67.43±1.96	63.73±1.25	62.17±1.59	63.57±0.25	63.50±0.87	61.97±2.68	64.13±0.55	64.80±1.11	65.77±0.32	63.87±1.58
CI	7.58±0.85	9.84±0.90	11.53±2.33	10.23±0.22	8.99±1.67	10.08±1.32	11.32±1.96	8.80±1.50	8.76±0.06	9.92±1.07

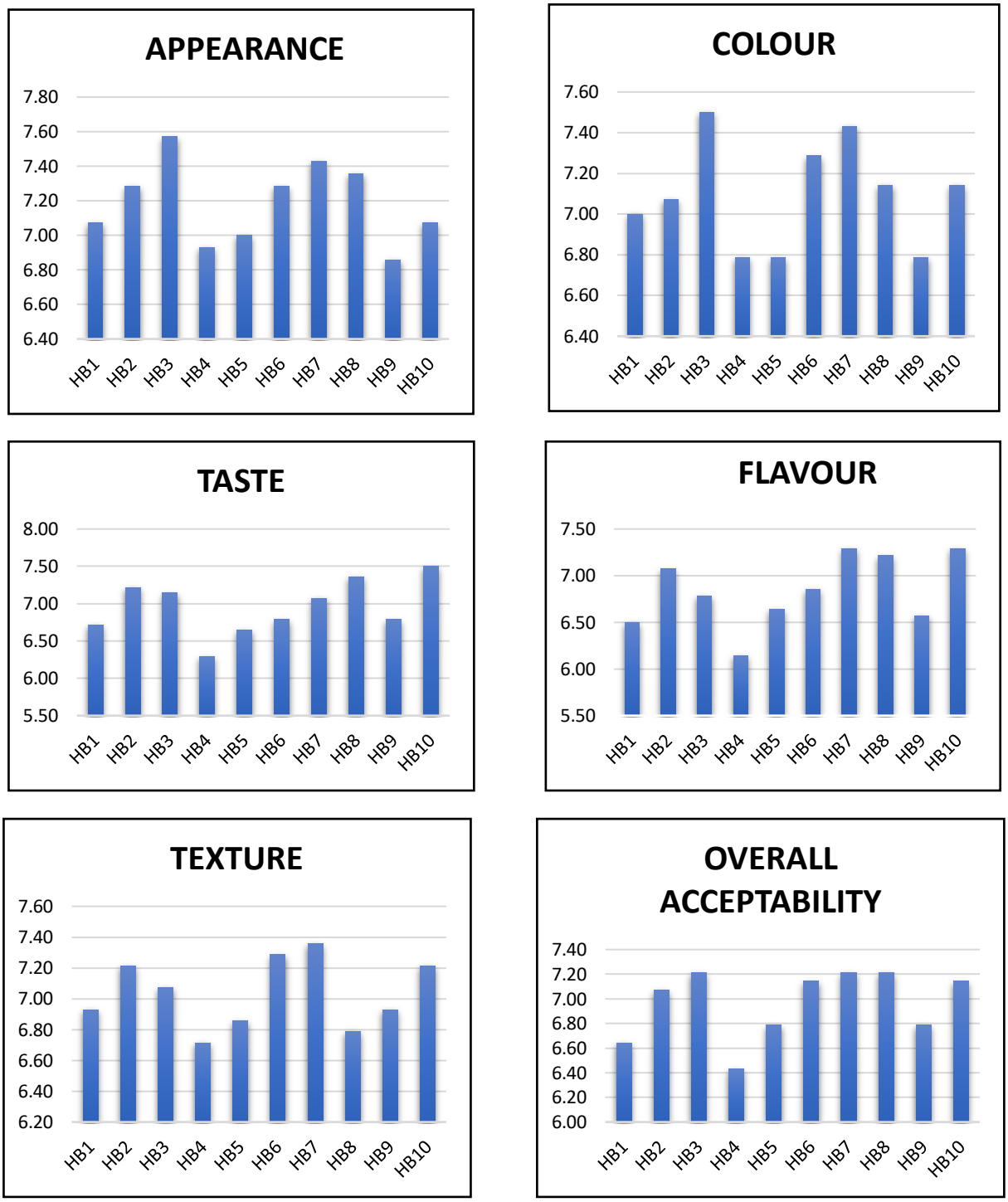

Fig. 2: Sensory evaluation of the developed products

4. CONCLUSION

The developed products were tested for physico-chemical properties and sensory attributes. Among the developed products, bars made with jaggery as binder was accepted by majority of the panel members (80%) in comparison to bars made with corn syrup. The developed snack bars provide high calorie with a good amount of protein and fat. The study focussed to formulate and develop high calorie bar by utilising locally available ingredients with special reference to millets due to its functional properties and to popularise the locally grown crops. Further, with improvement in taste and texture, these products can be given to malnourished subjects for providing instant energy.

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