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Formulation and evaluation of sorghum-based prototype meal replacement bar

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Abstract
The objective of the study was to develop a sorghum-based prototype meal replacement bar incorporating whey and soy proteins. In this study, bars were prepared with three combinations varying in flaxseed composition BS_1 (Sorghum-10%, Flaxseed-10%), BS_2 (Sorghum-15%, Flaxseed-5%), BS_3 (Sorghum-20%, Flaxseed-0%) keeping all others as constant. The Overall acceptability of the sensory evaluation (9-point hedonic rating scale) was analyzed with VETSTAT Software which was found to be more for BS_2 with 8.92 $\pm$ 0.08 and followed by BS_3, BS_1, and control (7.75 $\pm$ 0.25, 7.28 $\pm$ 0.16 and 7.20 $\pm$ 0.13) respectively. The energy value of the prototype meal replacement bar BS_2 was recorded as 256.84 $\pm$ 0.02 kcal/60g. The proximate analysis of the BS_2 meal replacement bar contained protein content of 13.19 $\pm$ 0.01g, fat content of 6.01 $\pm$ 0.01g, carbohydrate content of 32.81 $\pm$ 0.01g, crude fiber of 2.31 $\pm$ 0.12g, ash content of 1.25 $\pm$ 0.04g, and moisture content of 6.01 $\pm$ 0.01%. Thus, the prototype meal replacement bar finds its place in the new emerging products market to meet the appetite.

Keywords: Prototype meal replacement bar, sorghum, sensory and proximate analysis

1. Introduction
Meal replacement bars are a class of convenient food with a combination of protein, carbohydrates, healthy fats, and all the micronutrients needed to sustain optimal body function. They are widely considered a source of a balanced healthy diet in the changing lifestyle. A Meal replacer can be an effective solution for the working population to meet their hunger and appetite until the next meal.
Meal-replacement products usually provide 200 to 250 calories per serving, are fortified with more than 20 vitamins and minerals at "good" or "excellent source" levels, and often bear nutrient content claims, such as percent fat-free and reduced sugar (Yadav, 2020) [16]. Bars are proportioned and convenient composite foods, widely consumed as a potential meal replacer for supplying major nutrients in adequate quantities (Cabanilla *et al*., 2009) [1].
Sorghum is a gluten-free cereal (Kilambya and Witwer, 2013). It is rich in dietary fiber, minerals, and phenolic compounds (Dlamini, 2016). Flaxseed is emerging as one of the key sources of phytochemicals in the functional food arena. In addition to being one of the richest sources of α-linolenic acid, oil, and lignans, flaxseed is an essential source of high-quality protein and soluble fiber and has considerable potential as a source of phenolic compounds (Oomah, 2001). Hence, the present study is about the development of a prototype meal replacement bar.

2. Materials and Methods
2.1 Materials
The materials used in the development of the prototype meal replacement bar were Sorghum, Soya protein isolate (91% Protein Powder), Whey protein concentrate (80%), and Flaxseed. Xanthan gum, Liquid Glucose, Food grade Glycerin, Peanut Butter, Cocoa powder, Vanilla, and chocolate essence were procured online. Flatten rice, Peanut, Roasted Bengal gram, Pistachio, Jaggery, Raisin, Cocoa powder, and Iodized salt were purchased from the local market.
Food grade Vitamins like Vitamin A Vitamin B_1, Vitamin B_2, Vitamin B_6, Vitamin B_9, Vitamin B_{12}, Vitamin D_3, and Vitamin C and Minerals like Calcium carbonate, Ferrous Sulfate, and Zinc sulfate were purchased from Rose Pharmaceuticals and healthcare Pvt. Ltd, Karnataka.

2.2 Methods

2.2.1 Procedure for the formulation of meal replacement bars

The dry and wet ingredients were mixed along with vitamins such as vitamin A, B_1, B_2, B_6, B_9, B_{12}, C, and D and minerals like iron and zinc, based on the Recommended Daily Allowance (RDA) value requirement (ICMR, 2017). Vanilla and cocoa flavors were added to the meal replacement bar mix. The mix was molded to desired bar shape. The bar was baked in a pre-heated oven (5 minutes) at 160 ºC for 10 minutes. The bar was then cooled to room temperature and stored at ambient room temperature and refrigerated condition. Sensory evaluation, Physical and Proximate analysis of prototype meal replacement bars were carried out.

2.2.2 Sensory Evaluation

The sensory evaluation for all the developed meal replacement bars was evaluated for their Colour and appearance, Body and Texture, Taste, Aroma, Mouth-coating, and Overall acceptability attributes by a semi-trained panel using a 9-point Hedonic rating scale card with scores ranging from 9 to 1 (like extremely and dislike extremely) Lyon *et al.*, (2012) [8]. The high ratings of attributes Sorghum formulated bar with were further analyzed for Physical properties and Proximate content analysis.

2.2.3 Physical properties of Sorghum-based Prototype Meal replacement Bar

The Physical Properties of the Sorghum-based Prototype Meal replacement Bar were measured.

2.2.4 Proximate analysis of Sorghum-based Prototype Meal replacement Bar

The proximate analysis of the developed Prototype meal replacement bar formulations was performed by instrumental methods. Moisture content (Hot air oven, Technico scientific Instrumentation India Pvt. Ltd., at 105 ^{0}C), Fat content (Soxtron, Tulin equipment, Chennai), Ash content (muffle furnace, Hasthas scientific Instrumentation India at 550 ^{0}C), Protein content (Kjeltron Tulin Equipment, Chennai), and Crude fiber content (Fibrotron Tulin Equipment, Chennai) were analyzed. The carbohydrate content was estimated by the percent differential method. The calorific value was calculated by applying calorie conversion factors to carbohydrates (4 kcal/g), proteins (4 kcal/g), and lipids (9 kcal/g) and are expressed as kcal/100g.

2.2.5 Statistical analysis

VETSTAT software was used for statistical analysis and the results were given as Mean ± Standard Error (SE).

3. Result and Discussion

3.1 Optimization of levels of Sorghum and flaxseed for the preparation of Prototype Meal Replacement Bar.

Blends of sorghum and flaxseed were taken in three varying proportions (BS_1, BS_2, and BS_3) with different levels of sorghum (10, 15, and 20%) for the preparation of the prototype meal replacement bar Table 1.

Table 1: Formulation of Prototype Meal Replacement Bar

S. No.	Ingredient	Variation (%)		
1.	Sorghum	10	15	20
2.	Flaxseed	10	5	-
3.	Whey protein concentrate (80%)		5	
4.	Soya Protein isolate (91%)		5	
5.	Xanthan gum		0.5	
6.	Vitamins		0.6	
7.	Minerals		0.4	
8.	Flavor		0.7	
9.	Jaggery		15	
10.	Roasted Peanut (*Arachis hypogaea*)		5	
11.	Roasted Bengal gram		5	
12.	Pistachio		5	
13.	Glycerin		15	
14.	Peanut Butter		5	
15.	Raisin		5	
16.	Liquid Glucose		5	
17.	Cocoa Powder		5	
18.	Poha		5	
19.	Salt		0.3	
20.	Curcumin		0.5	

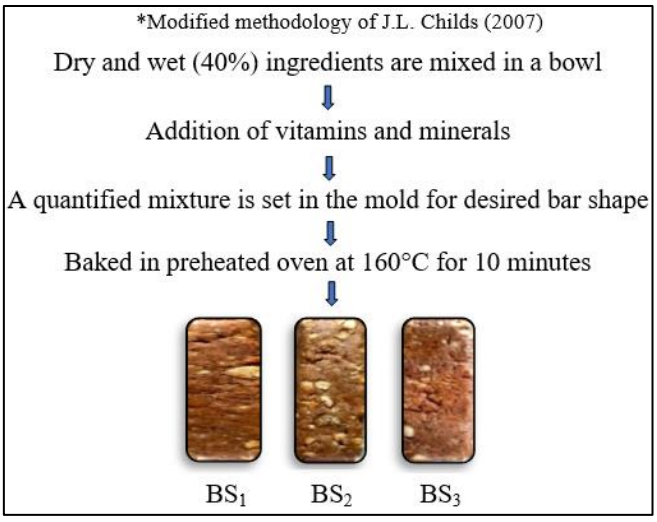

Fig 1: Flow chart for preparation of meal replacement bar

*BS_1 10% sorghum, 10% flaxseed
*BS_2 15% sorghum, 5% flaxseed
*BS_3 20% sorghum, 0% flaxseed

3.2 Sensory evaluation of millet-based Prototype meal replacement bar

From sensory scores given in Table 2, it is observed that the Colour and Appearance attributes ranged from 6.67 ± 0.21 to 8.33 ± 0.21. The highest value was observed in BS_2 and the lowest was recorded in the control sample and all the values of colour and appearance among the bars significantly differed (p<0.05). The difference may be due to the addition of flaxseed to the bars, with decreased lightness and increased redness, similar results were reported by Khouryieh and Aramouni (2013) [6] in the bars incorporated with Flaxseed bars. Body and Texture attribute values range from 6.50 ± 0.21 to 8.67 ± 0.21. The highest value was observed in BS_2 and the lowest was recorded in the control sample and all the values of body and texture among the bars significantly differed (p<0.05). The attribute aroma was within the range of 8.27 ± 0.30 to 8.67 ± 0.17, the highest value was observed in BS_2 and the lowest was recorded in the control sample at 8.27 ± 0.30 and all the values for the aroma of the bars were found with no significant difference (p<0.05) as the control sample and BS_2 Sample had similar flavoring agents. The taste attribute was absorbed from 7.17 ± 0.11 to 8.92 ± 0.08. The highest value was observed in BS_2 and the lowest was recorded in the control sample and all the values of taste among the bars significantly differed (p<0.05) Lower flavor and taste scores could be influenced by the beany flavor of sorghum after baking. This was also observed in the formulation of a sorghum cowpea complementary food for school-aged children. Dlamini *et al.*, (2016). The Mouth Coating attribute varied from 7.08 ± 0.15 to 8.83 ± 0.11. The highest value was observed in BS_2 and the lowest was recorded in the control sample and all the values of mouth-coating among the bars significantly differed (p<0.05). Finally, the Overall Acceptability was in the range of 7.20 ± 0.13 to 8.92 ± 0.08. The highest value was observed in BS_2 and the lowest was recorded in the control sample and all the values of overall acceptability among the bars significantly differed (p<0.05) and are represented in Table 2. Pereira *et al.* (2019) [11] analyzed the functionally enriched cereal bar with whey protein isolate was more appreciated by consumers, without affecting sensory characteristics. BS_2 bar with 15% of sorghum and 5% flaxseed with other ingredients received an overall acceptability score of 8.92 ± 0.08 and was highly accepted by testing semi-trained panel members. The developed bar was compared with the market sample taken as control with an overall acceptability score of 7.20 ± 0.13 and was found to be less acceptable. The result showed overall acceptability scores for BS_1 in the range of 7.28 ± 0.16 and BS_3 7.75 ± 0.25 respectively. As reported by Verma *et al.* (2018) [15] that protein-enriched cereal and energy-enriched cereal bars were "liked very much" without affecting the sensory qualities.

Table 2: Sensory attributes of Sorghum-based prototype Meal Replacement Bar in varying formulations using a 9-point hedonic scale

Treatments	Sensory attributes					
	Colour and Appearance	Body and Texture	Aroma	Taste	Mouth Coating	Overall Acceptability
Control	6.67 ^{a} ± 0.21	6.67 ^{a} ± 0.21	8.27 ± 0.30	7.17 ^{a} ± 0.11	7.08 ^{a} ± 0.15	7.20 ^{a} ± 0.13
BS_1	8.17 ^{b} ± 0.31	7.33 ^{b} ± 0.21	8.33 ± 0.21	7.42 ^{a} ± 0.20	8.67 ^{b} ± 0.31	7.28 ^{a} ± 0.16
BS_2	8.33 ^{b} ± 0.21	8.67 ^{c} ± 0.21	8.67 ± 0.17	8.92 ^{b} ± 0.08	8.83 ^{b} ± 0.11	8.92 ^{b} ± 0.08
BS_3	8.00 ^{b} ± 0.37	6.50 ^{a} ± 0.21	8.33 ± 0.21	7.67 ^{a} ± 0.21	8.42 ^{b} ± 0.20	7.75 ^{a} ± 0.25
F Value	6.04**	27.16**	NS	23.51**	4.01*	22.25**

@ Average of six trials (Different superscript in a same row and column differs significantly)
NS – Non-Significant (P>0.05) ** Highly significant (P<0.01) * Significant (P<0.05)

Control Market sample
BS_1 Prototype Meal replacement bar with - 10% sorghum
BS_2 Prototype Meal replacement bar with - 15% sorghum
BS_3 Prototype Meal replacement bar with - 20% sorghum

3.3 Physicochemical properties of Sorghum-based prototype meal replacement bar

Sorghum-based prototype meal replacement bar (BS_2) was found to be highly accepted from the sensory evaluation. The Physico-chemical analysis of the finalized prototype meal replacement bar such as moisture content, protein content, fiber content, fat content, and ash content are presented in Table 3. The mean moisture content of the millet-based prototype meal replacement bar was 6.01 ± 0.01%. The lower moisture content ensures the prevention of microbial growth and elongates the shelf-life stability of the product, hence is an important feature in food preservation. Souza *et al.* (2014) reported 7.19 - 8.24% moisture content that made cereal bars with whole flour of pseudo-cereals new cultivars. The amount of ash content present in a food product plays a significant role while determining the levels of essential minerals. Ash content of the prototype meal replacement bar was found 1.25 ± 0.04%, the results conformed with the results of the pumpkin seed flour-based bar Silva *et al.*, (2014) [13] with ash % ranging from 1.21 ± 0.12 to 1.8 ± 0.12. The protein content of the prototype meal replacement bar was efficient 13.19 ± 0.01% which could be attributed to the increased addition of flaxseed, WPC, and SPI. This was in line with the work of Diksha Sharma *et al.*, (2021) on the Development and storage stability of multi-seed energy bars for sports persons which were found to be with a similar value of 10.28 - 13.28%. The fat content for BS_2 was 6.12 ± 0.01%, this was closer to the result obtained by Nadeem *et al.* (2012) [9] who reported 5.52 - 8.37% fat content of protein-enriched dates bar. In addition to proximate values, the bars contain vitamins and minerals. These vitamins and minerals include a premixed combination of Vitamin A, Vitamin B_1, Vitamin B_2, Vitamin B_6, Vitamin B_{12}, Vitamin C, Vitamin D, Vitamin E, Vitamin K, Biotin, Calcium, Copper, Folic Acid, Iodine, Iron, Magnesium, Manganese, Pantothenic Acid, Phosphorus, and Zinc with was reported similar to the findings of Jan *et.al*, (2012) [5] in the preparation of nutritional bar for lactating women.

Table 3: Proximate analysis of Sorghum-based prototype Meal Replacement Bar

Parameter	Percentage/bar
Energy (Kcal)	256.84 ± 0.02
Moisture (%)	6.01 ± 0.01
Protein (%)	13.19 ± 0.01
Fat (%)	6.12 ± 0.01
Crude fiber (%)	2.31 ± 0.12
Ash (%)	1.25 ± 0.04
Total carbohydrate (%)	32.81± 0.01

3.4 Physical parameters of the Sorghum-based Prototype meal replacement bar

The physical parameters for the Sorghum-based Prototype meal replacement bar were developed and measured. The weight of the bar per serving was measured to be 60.10 ± 0.50 (g) with 10.20 ± 0.47 (cm) length, 3.5 ± 0.33 (cm) width, and thickness of 1.5 ± 0.13 (cm) on the bases of an average of six trials.

4. Conclusions

The developed Sorghum-based prototype Meal Replacement Bar (BS_2) with Sorghum-15% and Flaxseed-5% presented pleasing sensory attributes (appearance, colour, texture, flavor, overall acceptability) with greater acceptance. The BS_2 formulation resulted in a product with a higher nutritional value, meeting the classified RDA requirements and current demands of the consumer market with higher overall acceptability and energy value. Thus, an alternative instant healthy prototype meal replacement food is developed for convenience. Further studies may be done to extend the storage studies of the developed bars.

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