

FORMULATION AND OPTIMIZATION OF HERBAL GRANOLA BAR USING FACTORIAL DESIGN

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ABSTRACT

The experimental work was carried out in 2022-2023 in SVU college of sciences, Sri Venkateswara University, Tirupati. The main aim was to design a herbal granola bar and its optimization using factorial design. Factorial design was used to determine the significant factors and the optimal condition of the process variable. The factors considered for the study were gum acacia (stabilizer/Gum acacia) and dried herb powder, and the responses were mouth feel, colour and overall acceptability. In the study, increase in colour values of the product was observed with added levels of *Centella asiatica* herb powder up to 6 percent, although irreversible effect was observed at the level of 8 percent. The mouth feel values of the herbal granola bar formulations containing different levels of *Centella asiatica* herb powder and gum acacia reveals that the main effect plot shows that the addition of *Centella asiatica* herb powder up to 6 percent markedly increased the mouth feel values of product. Addition of *Centella asiatica* herb powder up to 6 percent did not affect the taste of the product, however at the level of 8 percent the formulated product perceived the specific medicinal herb taste and flavour in herbal granola bar. Finally, the sensory attributes in terms of overall acceptability of formulations containing 6 percent *Centella asiatica* herb powder and 1.5 percent level of gum acacia were best and well accepted.

Keywords: *Centella asiatica*, Granola bar, Herb, Optimization.

INTRODUCTION

In India, herbs/medicinal plants have been used under a medical system Ayurveda since 5000 years (Jamshidi-Kia *et al.*, 2017). This system includes diet and herbal remedies specifically to the body, mind and spirit for disease prevention and treatment. In addition to the macro and micro nutrients such as proteins, fats, carbohydrates, vitamins or minerals necessary for normal metabolism, a

plant based diet contains numerous non-nutritive phyto-constituents which may also play an important role in health enhancement. The utilization of herbs will encourage variety in food intake and support nutrient diversity by encouraging new food choices. The food products based on herbs/medicinal plants are quite limited. There are few constraints faced by the food industry to incorporate herbs/medicinal plants as an ingredient into the food

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matrix. Because, each herb/medicinal plant has their characteristic aroma and taste that can easily change the product unique characteristics. Ultimately, it may show an impact on acceptability of the product. *Centella* herb, which has mild bitter taste and acceptability, can be incorporated into suitable food products. Medicinal plant sector has an important position in the socio-cultural, spiritual and medicinal arena of rural and tribal lives of India (Alamgir, 2017).

Demand is increasing rapidly for the processed and convenience foods because of the increasing awareness about the health, changing socio-economic needs, and insufficient time to cook food with the correct/balanced amount of nutrition (Sushant *et al.*, 2021). One such nutritionally balanced convenience food is the nutritious granola bars, which are acquiring popularity in the worldwide market. Granola bars are products obtained from the compression of grains, containing nuts, dried fruits, flavorings and binder ingredients. The bars contain wide range of nutrients as well as sufficient amount of carbohydrates, proteins and fats and are accessible in smaller packets or pouches, light in weight, very convenient to carry and can be eaten at any point of time (Sharma *et al.*, 2014). According to a recently published report by TechSci Research - India Nutrition Bars Market Forecast and Opportunities, 2020, the nutrition bars market in India is anticipated to grow at a CAGR (Compound Annual Growth Rate) of more than 29% during 2015- 2020 on account of increasing working population, rising per capita expenditure, growing incidences of lifestyle diseases and surging youth population.

Centella asiatica comprises a broad spectrum of phytonutrients that provide a range of beneficial effects (Seevaratnam *et al.*,

2012). Generally, *Centella asiatica* contains various classes of phytonutrients such as triterpenes, carotenoids, glycosides, flavonoids, alkaloids, volatile oils and fatty oils (Chandrika and Kumara, 2015). Every research suggests that it is a “miracle herb” for all kind of treatment. It has a cosmic effect on different organs like brain, skin, heart, gastro intestinal system, collagenous tissues and also possesses strong antioxidant properties. Nutritionally, combining cereal grains with other ingredients are valuable to provide better nutrition (McKevith, 2004). By changing and adding additional ingredients, nutritional value of granola bars can be altered. Along these lines, granola bar was chosen to provide value addition with the herb/medicinal plant i.e., *Centella asiatica* in the current study. The food industry has been developing and launching cereal and millet based, fruit based and multi grain bars into the market. Herbs and products containing herb(s) have been in exchange and business and are presently utilized for an assortment of purposes (Awuchi, 2019). Herbal based food products particularly in granola bar market are almost absent. After reviewing the literature on herbal food products with reference to *Centella asiatica*, very limited research studies are available. By keeping in view of it, the research work was planned to design a herbal granola bar and its optimization interms of its composition and quality.

MATERIAL AND METHODS

Medicinal herbs/medicinal plants are gaining interest now a days because of its various health benefits. Granola bars are very adaptable products made from processed cereals mixed with a variety of ingredients. In this context, in development of herbal foods, granola bar was chosen with value addition by *Centella asiatica* in the current study. The methodology adopted for the research work is given as follows.

Processing of herb-*Centella asiatica*

The leaves and the aerial part of the *Centella asiatica* plants were used. The leaf tissues were found to have higher triterpenoids content than the callus and cell suspension. Fresh fully matured leaves of *Centella asiatica* were collected from Krishi Vignana Kendra, Tirupati. A voucher specimen was prepared and tested by the experts with a sample of *Centella asiatica* species from the Department of Botany, SVU, Tirupati. The collected leaves were washed thoroughly to remove the adherent dust particles and cleaned leaves were kept for shade drying about 2 hours. The Cabinet drier was used to decrease the moisture by maintaining the temperature about 40°C (24

hrs) and to retain the maximum nutrients of *Centella asiatica*. Then the dried herb/ medicinal plant leaves were ground into a coarse powder with the help of mixer and stored in an airtight container.

Procurement of ingredients

Good quality of selected ingredients (Table 4) were procured from local super market, Tirupati. These ingredients were selected based on the functional compounds present in them which will provide value addition to the product. Stabilizers and emulsifiers such as Gum Acacia and liquid glucose were purchased from online sources.

Table 1. Experiments conducted for optimization of herbal granola bar

S.No	<i>Centella asiatica</i> herbpowder (%)	Gum acacia (%)
Experiment 1		
1	2.0	0.5
2	2.0	1.0
3	2.0	1.5
4	2.0	2.0
Experiment 2		
5	4.0	0.5
6	4.0	1.0
7	4.0	1.5
8	4.0	2.0
Experiment 3		
9	6.0	0.5
10	6.0	1.0
11	6.0	1.5
12	6.0	2.0
Experiment 4		
13	8.0	0.5
14	8.0	1.0
15	8.0	1.5
16	8.0	2.0

Formulation and Optimization of Herbal Granola Bar

Demand for the processed and convenience foods is increasing rapidly due to the increasing awareness about the health, changing socio-economic needs, and insufficient time to cook food with the correct/balanced amount of nutrition. For the formulation of highly acceptable granola bar, different proportions of ingredients were selected. The formulations were worked out to design and optimize the herbal granola bars follows.

Formulation

The primary objective of the current study is to design herbal granola bar. Hence, to get desirable characteristics, various trials were made with different formulations where major emphasis was given to herb powder at different compositions. Totally sixteen trials with four experiments were conducted for the optimization of herbal granola bar. The experiments conducted for the optimization of herbal granola bar are given in table 1.

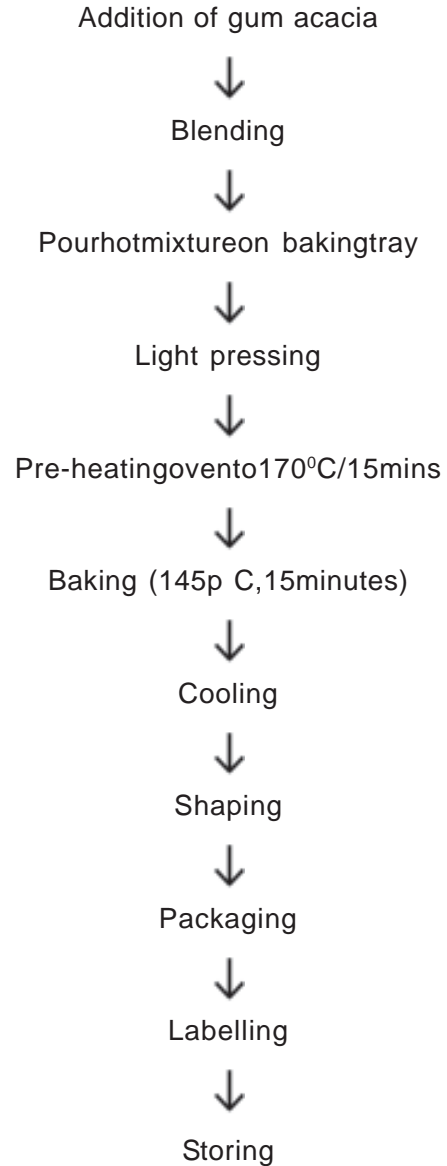
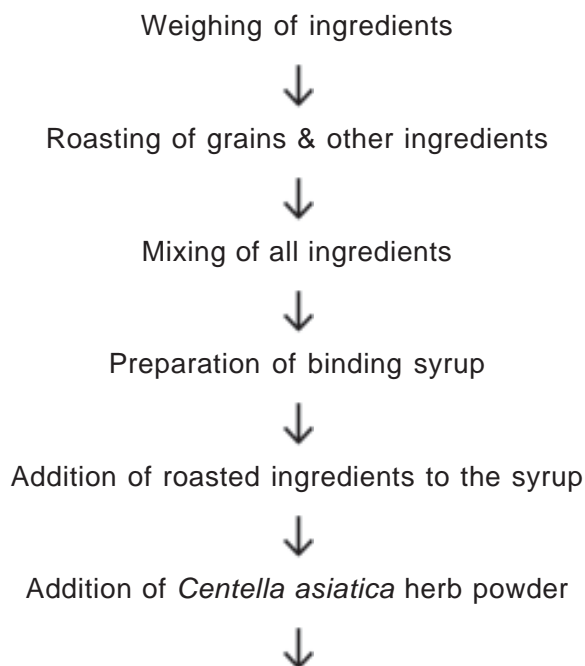


Fig.1. Formulation of Herbal Granola Bar

Optimization

Herbal granola bar was optimized by using factorial research design. An experiment containing two factors, or even more than two, is considered a factorial experiment (related to treatment structure only). Factorial design was used to determine the significant factors and the optimal condition of the process variable. The factors considered for the study were Gum acacia (stabilizer) and dried herb powder, and the responses were mouth feel, colour and overall acceptability.

FORMULATION AND OPTIMIZATION OF HERBAL GRANOLA BAR

Table 2. Results subjected for optimization of herbal granola bar

S.No	<i>Centella asiatica</i> herb powder(g)	Gum acacia (g)	Responses		
			Mouthfeel	Colour	Overallac ceptability
Experiment 1					
1	2.0	0.5	6	5	6
2	2.0	1.0	6	5	7
3	2.0	1.5	6	5	7
4	2.0	2.0	7	5	6
Experiment 2					
5	4.0	0.5	7	6	7
6	4.0	1.0	7	6	7
7	4.0	1.5	7	6	7
8	4.0	2.0	6	5	7
Experiment 3					
9	6.0	0.5	8	7	7
10	6.0	1.0	8	7	6
11	6.0	1.5	8	8	8
12	6.0	2.0	8	6	6
Experiment 4					
13	8.0	0.5	4	5	4
14	8.0	1.0	5	4	5
15	8.0	1.5	4	5	5
16	8.0	2.0	4	4	4



Herbal Granola Bar

Table 3. Optimization of herbal granola bar using factorial research design

Experim- ental Run	<i>Centella asiatica</i> herb powder(g)	Gum acacia (g)	Responses		
			Mouthfeel	Colour	Overall ac- ceptability
1	2	0.5	6	5	6
2	2	1	6	5	7
3	2	1.5	6	5	7
4	2	2	7	5	6
5	4.0	0.5	7	6	7
6	4.0	1	7	6	7
7	4.0	1.5	7	6	7
8	4.0	2	6	5	7
9	6.0	0.5	8	7	7
10	6.0	1	8	7	6
11	6.0	1.5	8	8	8
12	6.0	2	8	6	6
13	8.0	0.5	4	5	4
14	8.0	1	5	4	5
15	8.0	1.5	4	5	5
16	8.0	2	4	4	4

Minitab statistical software was used to create the full factorial design with four levels of two factors. Sixteen combinations of two variables were replicated twice and the results were averaged and used for the statistical analysis (table 2). The main and interaction effects of added ingredients on the colour, mouthfeel and OAA were analysed through general linear model regression analysis with analysis of variance (ANOVA). The data was subjected to analysis of variance by using the statistical analysis system (Co Stat version 6.204, CoHort Software, Monterey, California, USA). Student- NewmanKeuls test ($p < 0.05$).

RESULTS AND DISCUSSION

The results obtained were subjected to statistical analysis and are presented as follows. Optimization of herbal granola bar Minitab statistical software was used to create

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Sixteen combinations of two variables were replicated twice and the results were averaged and used for the statistical analysis (Table 3). The main and interaction effects of added ingredients on the colour, mouth feel and overall acceptability were analyzed through general linear model regression analysis with analysis of variance (ANOVA). The data was subjected to analysis of variance by using the statistical analysis system (Co Stat version 6.204, CoHort Software, Monterey, California, USA). Student- NewmanKeuls test ($p < 0.05$) was used to resolve the difference among the samples.

Colour

The results of sensory evaluation are very prominent with different herbal granola

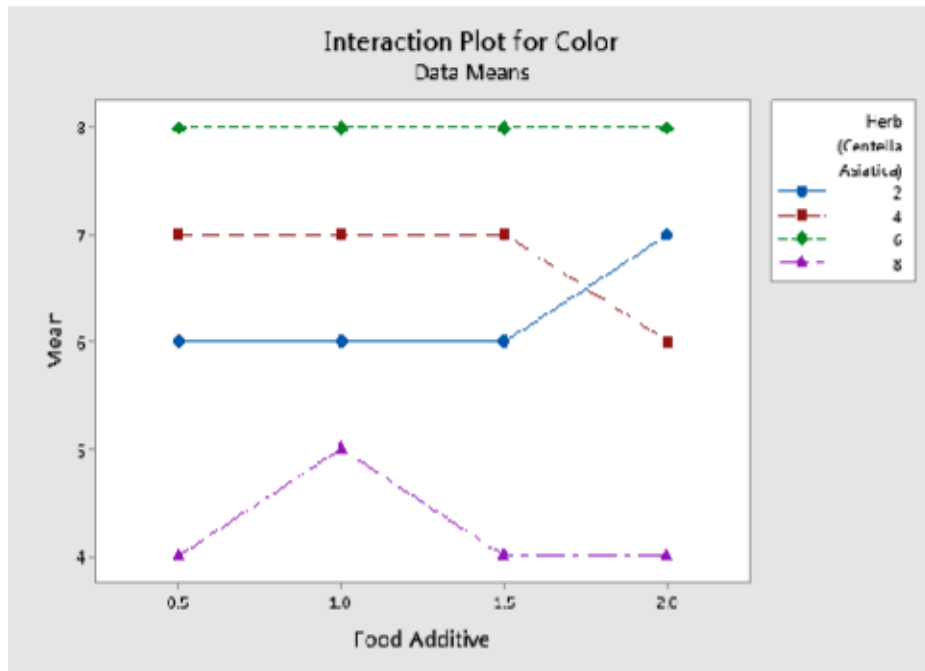


Fig.2.Effect of factors on colour of herbal granola bar

bar formulations prepared with varying levels of Gum acacia and *Centella asiatica* herb powder combinations. The influence of the selected factors i.e. *Centella asiatica* powder and Gum acacia on the colour of herbal granola bar is presented fig 2.

In the current study, increase in colour values of the product was observed with added levels of *Centella asiatica* herb powder up to 6 percent, although irreversible effect was observed at the level of 8 percent. The addition of gum acacia did not much affect the colour of the product. The changes in colour values might be due to the pigments which were present in *Centella asiatica*. In the current study results, the formulations seemed to be highly influenced by the levels of *Centella asiatica* herb powder and their interactions. Overall, the results revealed that the colour of formulation which contains 6 percent *Centella asiatica* herb powder and 1.5 percent of gum acacia was best among all samples. Mrudula *et al.* (2017) conducted a study on development, quality evaluation and shelf life studies of extruded

herbal snack foods with fortified herb (*Ocimum basilicum*). The herbal snack was developed by incorporating different proportions of *Ocimum basilicum* paste. According to these results, during the storage period of 60 days of prepared samples, it was observed that the sensory attributes of the samples both control and experiment, were slightly decreased respectively. But the sample which is having ocimum paste has more palatability i.e., the acceptability of this sample was a way more acceptable compared with other samples.

Mouth feel

The mouth feel values of the herbal granola bar formulations containing different levels of *Centella asiatica* herb powder and gum acacia are shown in table 3. The main effect plot shows that the addition of *Centella asiatica* herb powder up to 6 percent markedly increased mouth feel values of product. But with the addition of 8 percent *Centella asiatica* herb powder, the values for mouth feel were decreased. It might be due to the specific taste

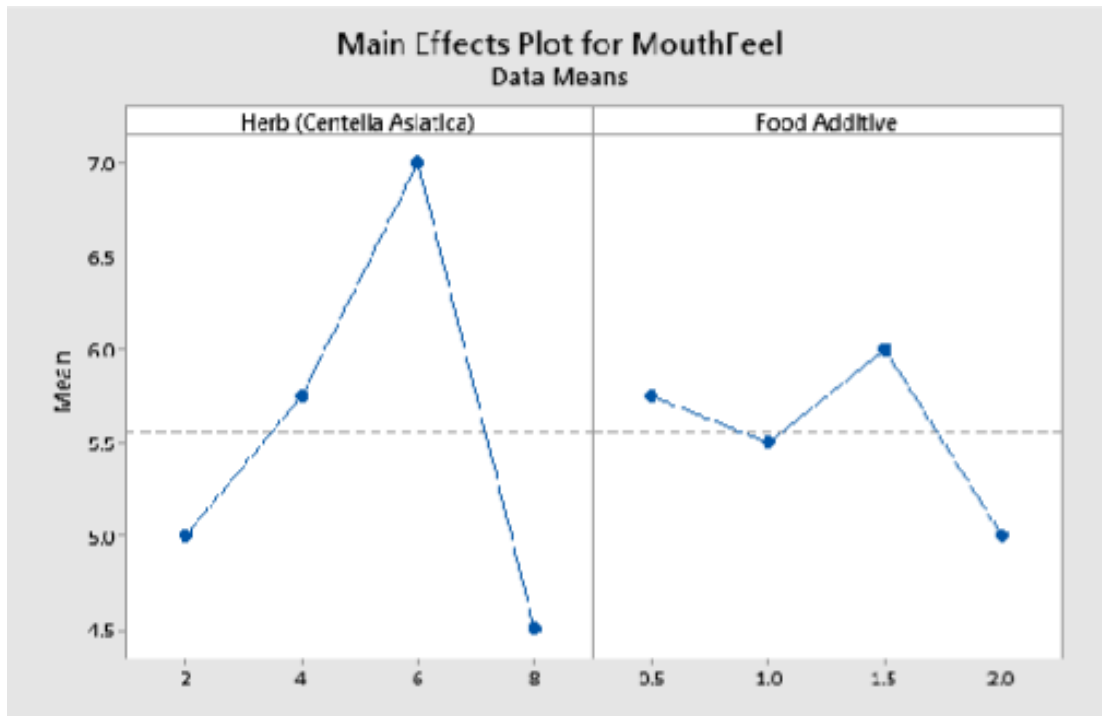


Fig.3.Effect of factors on mouthfeel of herbal granola bar

and flavour of particular medicinal herb. The effect of the selected factors i.e. *Centella asiatica* herb powder and gum acacia on the mouth feel of herbal granola bar was presented in fig 3.

Overall acceptability (OAA)

Overall acceptability is a measure which generally influenced by all sensory properties of food. The influence of the selected factors i.e. *Centella asiatica* herb powder and gum acacia on the overall acceptability of herbal granola bar was presented in fig 4. The increase in overall acceptability (OAA) of the product was observed with added levels of *Centella asiatica* herb powder, although irreversible effects were observed at the level of 8 percent addition. Addition of *Centella asiatica* herb powder up to 6 percent did not affect the taste of the product, however at the level of 8 percent the formulated product perceived the specific medicinal herb taste and flavour in herbal granola bar. Finally, the sensory attributes of formulations containing 6 percent *Centella*

asiatica herb powder and 1.5 percent level of gum acacia were best and rated upper part and well accepted. Ramakrishna *et al.* (2015) developed a product labeled Nutraceutical enriched Indian traditional chikki. They formulated and standardized chikki with added herbs like ashwagandha (*Withania somenifera*), tulasi (*Ocimum sanctum* L.) and ajwain (*Trachyspermum ammi* S.). Storage studies were carried out for the developed products up to 90 days. Their results revealed that, sensory analysis of chikki prepared with the addition of herbs showed high acceptance. Significant differences were also observed for colour, flavour and crunchiness among the samples.

Standardization of herbal granola bar

Herbal granola bar was standardized with optimized ingredient composition obtained in full factorial design with four levels of two factors. The table 4 shows the ingredient composition used to design the herbal granola bar. The factors which were optimized were

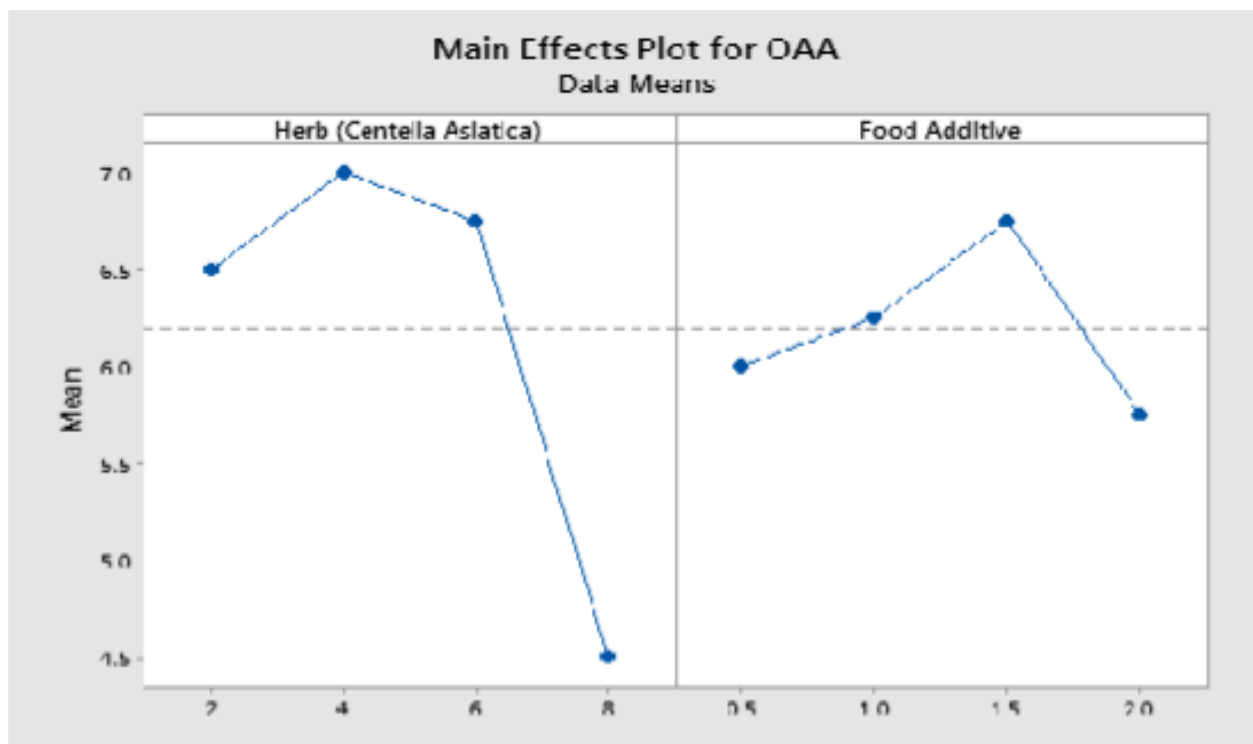


Fig.4.Effect of factors on OAA of herbal granola bar

Table 4. Standardized and optimized composition of Herbal Granola Bar

S. No.	Ingredients	Quantity (g)
1	Foxtail millet flakes	8.0
2	Bajra flakes	8.0
3	Soychunks	8.0
4	Organic rolled oats	8.0
5	Pumpkin seeds	4.5
6	Flax seeds	4.5
7	Sesame seeds	4.5
8	Chia seeds	4.5
9	Raisins	5.0
10	Fresh dates	5.0
11	Sugar	25
12	Honey	5.0
13	Glucose syrup	3.0
14	Gum acacia	1.5
15	Cocoa powder	2.5
16	Skimmed Milk Powder	3.0
17	<i>Centella asiatica</i> powder	6.0

taken as optimal composition for designing the final herbal granola bar.

Many herbs have been proven for its bioactive components and their potential to decrease many risk factors. Therefore addition of medicinal herbs into granola bars could help to provide value added herbal granola bars with enhanced nutritional and medicinal values. The present study results revealed that the nutritional properties of *Centella asiatica* and binding properties of gum acacia brought conspicuous changes in the product quality. The important interactions between the appropriate levels of *Centella asiatica* herb powder and gum acacia are eventually important for a highly acceptable product. The combination of 6% *Centella asiatica* herb powder and 1.5 % of gum acacia was found to be the best combination for the development of herbal granola bar with optimum quality characteristics. Kamalesh *et al.* (2021) conducted a study on the influence of chocolate fortification with *Centella asiatica*, *Abelmoschus esculentus* and *Psidium guajava* on the content of biologically active substances. Their research examined the combination of *Centella asiatica*, *Abelmoschus esculentus*, and *Psidium guajava* in the process of chocolate formulation. The concentration of the product was optimized based on taste, flavour, texture, and stability. The optimized concentration was subjected to Nutritional, Stability, Sensory, Antioxidant, Antimicrobial and Shelf life analysis.

The demand for healthy, nutritious and safe food is growing worldwide and consumers are taking the forward step towards natural healthy food products. The use of *Centella asiatica* in the formulation of the herbal granola bar has provided higher nutritional values and it will suitable to the current consumers due to its high levels of antioxidants and

phytochemicals. Herbal granola bar developed by using a variety of functional ingredients can be introduced into the commercial market for various segments of consumers concerned about nutritious and healthy foods. Herbal granola bar could meet this trend with their rich source of phytonutrients.

The cost of production of one kg herbal granola bar was about Rs. 434.64/- and each bar (approximately of 30 gm) is Rs. 14.48/-. This was comparatively very less than any commercial bars that are available in market. By the incorporation of medicinal herb powder, this will provide nutritional and therapeutic benefits to the consumer. This herbal granola bars can be prepared / manufactured at home, cottage and industrial scale to meet the consumer demands, nutritional security and healthy life to population.

CONCLUSION

The sensory attributes of formulations containing 6 percent *Centella asiatica* herb powder and 1.5 percent level of gum acacia were best and well accepted. The current study thus concludes that nutrifoods such as herbal granola bars are intended to not only provide essential macro and micronutrients to the body but also to supply it with bioactive ingredients that aid to decrease nutrition-related diseases and ensure physical and mental well-being. With rapid advances in food technological research, active ingredients from herbs/medicinal plants served as key ingredients for the development of novel food products. Granola bars have been a good choice to test the novelty in the products because of increasing demand in global convenience health/functional food product market. Combination of herbs/medicinal plants in formulating granola bars with gifted health benefits and to avoid any side effects with respect to quality testing, safety and price.

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