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Effect of type of sweetener on the sensory parameters of protein bars

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Abstract
Protein bars from different sweetener source were formulated and their sensory acceptability was evaluated. A total of nine bar formulations were developed. Jaggery and corn syrup were used as sweeteners, which were added at different levels namely 40, 44 and 48 percent and their combinations J:C = 50:50, J:C = 60:40, J:C = 40:60 (J-Jaggery, C-Corn syrup) along with the other ingredients. Evaluation of sensory acceptability of protein bars using 9-point hedonic scale score card showed higher total mean sensory scores (MSS) and acceptability index (AI) values in formulations made with jaggery compared to formulations prepared with corn syrup. Protein bars with 44 percent jaggery scored highest total mean sensory score (46.4) and acceptability index (86) followed by those with 48 percent (MSS-45.9; AI-85) and 40 percent jaggery (MSS-45.3; AI-84) respectively. Further the combination of jaggery and corn syrup at J:C = 60:40 also gave comparable results (MSS-45.3; AI-83).

Keywords: Sensory evaluation, sweetener, protein bar, jaggery, corn syrup

Introduction
Protein bars are nutrition bars that contain a high proportion of protein to carbohydrates/fats, where the bar delivers at least 20 percent of the recommended daily requirements of sedentary workers for protein per 100 g for claiming/labelling as high-protein/protein rich product under the Food Safety and Standards Amendment Regulations (Advertising and Claims) (FSSAI, 2019) [5]. Protein bars were once marketed to athletes and competitors, but now a day are formulated, marketed, and sold to the everyday consumer.

Typically, commercial protein bars are composed of two main ingredients: powdered proteins from soy or dairy sources and sugar or polyol-based syrups (Li *et al.* 2008) [9]. Sugars or polyol-based syrups which are the mixtures of crystalline sugars such as sucrose, dextrose, fructose, lactose and jaggery, and sugar syrups such as high-fructose corn syrup (HFCS), corn syrup, brown rice syrup and. glucose syrup.

Functionally sweetenerss play an important role in protein bars. Sweeteners not only makes bars more palatable but is also a bulking agent, adds viscosity, enhances flavour, provides texture, adds colour, is a preservative, and inhibits protein coagulation (Davis, 1995) [4]. They also help bind the bar- holding their shape and all the bar ingredients together, which also provide the desired chewy or crunchy texture in bar that consumers enjoy in bars. Sugar alcohols, (glycerol, sorbitol and maltitol) can also be used in protein bars as low-calorie sweeteners and for their humectant properties that have a water activity-lowering effect which makes water unavailable for bacteria and fungi growth (Adams, 2008; Loveday *et al.* 2010) [1, 10].

Jaggery or 'Gur' is a pure, wholesome, traditional, unrefined, whole sugar made by the concentration of sugarcane juice without the use of any preservatives. Jaggery is one of the ancient sweetening agents known to man and an energy food that is said to purify blood, regulate liver function and keep the body healthy (Mandal *et al.* 2006) [11]. Corn syrup (HFCS) is a liquid alternative sweetener to sucrose/jaggery that is made from corn providing sweetness nearly identical to table sugar (sucrose) is used in variety of foods and beverages as an alternative sweetener which has many advantages compared to sucrose that include its sweetness, solubility, acidity and its relative cheapness which make it attractive to food manufacturers. It gives chewy breakfast bars their soft texture and also protects freshness (Yadav and Bhatnagar, 2015) [16]. Sugar alcohols like xylitol, sorbitol, mannitol which are often used to sweeten protein bars. For some people, these sugars can cause intestinal gas, leading to irritable bowel symptoms such as intestinal pain, constipation or diarrhoea (Keefer *et al.* 2020) [8].

Therefore replacement of sugar alcohols with natural sweeteners from natural ingredients like jaggery and corn syrup and their combination can be healthier and serves the purpose of sweeteners. Thus, sweeteners' being one of the major ingredients in the protein bar preparation, selection and their quality evaluation is important for developing good quality protein bars.

Objective: The aim of this study was to formulate and evaluate the acceptability of protein bars from different sweetener source.

2. Materials and Methods

The present investigation was carried out in the department of Food Science and Nutrition, University of Agricultural Sciences (UAS), GKVK, Bengaluru. Procedure of standardization of protein bars prepared with varied proportion of two sweeteners and their sensory quality assessments is described below.

2.1 Procurement of raw materials

The ingredients used in preparation of protein bar *viz.* raw popped corn, soy protein isolate, jaggery, corn syrup, skim milk powder, palm oil and ground nuts were procured from local market. Popped corns are prepared by heating the raw pop corn kernels with little oil in a sauce pan at medium high heat and cooking by covering the pan until all the kernels are popped.

2.2 Preparation of protein bar

The jaggery based protein bars were prepared following an indigenous method used for the preparation of peanut candy with slight modification as depicted in Figure 1 (Pallavi *et al.* 2014) [15]. A preliminary trial was conducted to standardise the quantity of different ingredients required for the preparation of protein bars.

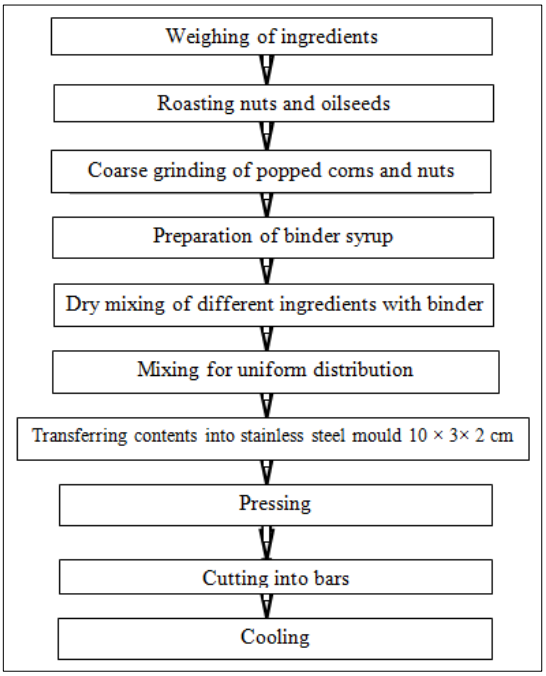

Fig 1: Formulation procedure for protein bars

A total of nine bar formulations were developed. The quantity of jaggery and corn syrup varied among the formulations, as presented in Table 1 and 2, which were added at different levels namely 40, 44 and 48 percent and their combinations J:C = 50:50, J:C = 60:40, J:C = 40:60 were used as sweeteners. (J-Jaggery, C-Corn syrup).

Table 1: Quantity (g/100g) of ingredients used for the standardization of sweeteners for protein bars

Ingredients	Types and levels of sweeteners in bars (g/100g)					
	J 40%	J 44%	J 48%	C 40%	C 44%	C 48%
Popped corn	10	9	8	10	9	8
Soy Protein Isolate	22	21	20	22	21	20
Skim milk powder	10	9	8	10	9	8
Ground nuts	10	9	8	10	9	8
Jaggery	40	44	48	.	.	.
Corn syrup	.	.	.	40	44	48
Palm oil	8	8	8	8	8	8
Total	100	100	100	100	100	100

Table 2: Combination of sweeteners (#) used for the standardization of protein bars

Ingredients	Levels of sweeteners in bars (#) (g/100g)		
	J:C = 50:50	J:C = 60:40	J:C = 40:60
Jaggery (J)	24	29	19
Corn syrup (C)	24	19	29
Popped corn	8	8	8
Soy Protein Isolate	20	20	20
Skim milk powder	8	8	8
Ground nuts	8	8	8
Palm oil	8	8	8
Total	100	100	100

Sweeteners constituted 48 percent of the bar formulation

2.3 Preparation of dry ingredients

Pop corns and roasted ground nuts were ground to coarse powder. All the ingredients namely ground popped corns, ground nuts, soy protein isolate and skim milk powder was dry mixed in a steel vessel.

2.4 Preparation of the binder syrup

In a non-stick pan previously weighed jaggery and palm oil was heated to a temperature of 105-110 °C by adding 10 ml of water to prepare the binder solution. The mixture was concentrated to get thick consistent syrup with 85 brix (soft ball stage) (Padmashree *et al.* 2012) [14]. To the hot binder syrup the above dry ingredients mixture was added and thoroughly mixed. Later the mass was transferred into the rectangular stainless steel mould with dimension of 22.5 cm x 24 cm x 2 cm and pressed firmly into the mould with a steel plate which enabled exertion of equal pressure on the bars. After pressing, it was cut in smaller bars of size 10 cm x 3 cm x 2 cm using bar cutter.

2.5 Sensory analysis

The developed product was evaluated by a semi trained panel members for attributes of appearance, texture, colour and over-all acceptability on a 9-point hedonic scale score card where score 9 was for liked extremely and 1 for extremely disliked samples.

a. Total mean sensory score (MSS): It is the sum of scores of all the sensory attributes (appearance, colour, texture, flavour, taste and overall acceptability).
b. Acceptability index (AI): Calculated using the following formula (Damasceno *et al.* 2016) [3].

$$AI\ \% = \frac{\text{Average score obtained for the product}}{\text{Highest score given to the product}} \times 100 \quad (1)$$

Fig 2: Protein bar samples

2.6 Statistical analysis
Sensory results were subjected to one way analysis of variance (ANOVA) at ($p \leq 0.05$) significance levels using Duncan's multiple range tests and statistical analysis was carried out by using the software SPSS 16.0 (2007).

3. Results
The results of effect of type of sweeteners on the sensory acceptability of protein bars are presented in Table 3. The mean sensory scores for all the sensory parameters for protein bars prepared with different levels of sweeteners varied significantly except for appearance which reveals that type of sweetener did not influence the appearance of protein bars. The mean sensory score for colour showed that the protein bars prepared with jaggery were superior in their colour scores at 44 percent (7.92) and 40 percent (7.90) level. The mean sensory score for texture showed that protein bars with jaggery scored better compared to the protein bars made from corn syrup. Highest level of jaggery i.e. 48 percent did not give good texture scores whereas protein bars prepared with 44 percent jaggery (7.33) gave good textured products. The mean sensory score for flavour and taste indicated that all the protein bars prepared with jaggery at different levels had higher scores when compared to the bars made from corn syrup. Among the protein bars prepared with jaggery 44 percent level scored highest for both flavour (7.63) and taste (7.87) parameter. Considering the mean sensory score for overall acceptability of protein bars revealed that bars prepared with jaggery had higher overall acceptability scores compared to corn syrup. Highest overall acceptability score was obtained for bar with 44 percent of jaggery (7.82) followed by 40 percent (7.7) and 48percent (7.6).
The results of effect of combination of sweeteners on the sensory acceptability of protein bars are given in Table 4. The mean sensory scores for all the sensory parameters for protein bars prepared with different combination of sweeteners (J:C = 50:50, J:C = 60:40, J:C = 40:60**;** J-Jaggery, C-Corn syrup) gave non-significant results except for taste and overall acceptability scores which suggest that the different combination of sweeteners influenced only in the taste and overall acceptability parameter of the products.
The total mean sensory score and acceptability index of protein bars prepared with different types and levels of sweeteners are given in Figure 3.

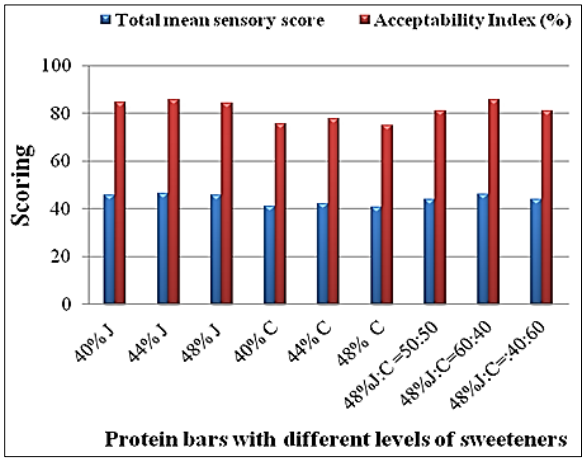

Fig 3: Mean sensory score and acceptability index of protein bars with different types and levels of sweeteners

Higher total mean sensory scores and acceptability index values were observed in the formulations made with jaggery compared to formulations prepared with corn syrup. Protein bars with 44 percent jaggery scored highest total mean sensory score and acceptability index followed by those with 48 percent and 40 percent jaggery. The combination of jaggery and corn syrup at 60:40 also gave comparable results of total mean sensory score and acceptability index.
The bird's eye view of the sensory data is seen in the spider web chart (Figure 4) shows the sensory analysis results in the form of a spider web. The sensory differences perceived by the panellists were significantly different except for the appearance and colour of samples which were quite similar. The appearance score of samples ranged from 7.5 to 7.8 whereas colour scores ranged from 7.0 to 7.9. The protein bar with 44 percent jaggery received significant higher score followed by 48 percent jaggery sample compared to the other protein bar samples for all the sensory attributes, whereas sample with 48 percent corn syrup scored least in all the sensory parameters.

Table 3: Sensory scores of protein bars prepared with different types of sweeteners

Types and levels of sweetener	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
Jaggery (40%)	7.90 ± 0.75	7.75 ± 0.66bc	7.26 ± 1.27c	7.60 ± 0.83b	7.60 ± 0.93b	7.70 ± 0.87b
Jaggery (44%)	7.80 ± 0.66	7.92 ± 0.85c	7.33 ± 0.97c	7.63 ± 0.78b	7.87 ± 0.95b	7.82 ± 0.89b
Jaggery (48%)	7.75 ± 0.68	7.90 ± 0.60c	7.07 ± 1.19bc	7.51 ± 0.58b	7.72 ± 0.78b	7.62 ± 0.94b
Corn syrup (40%)	7.59 ± 0.69	7.30 ± 0.74ab	6.38 ± 0.68a	6.31 ± 0.71a	6.48 ± 0.85a	6.79 ± 0.83a
Corn syrup (44%)	7.74 ± 0.58	7.31 ± 0.60ab	6.60 ± 1.13ab	6.64 ± 0.70a	6.74 ± 0.90a	6.90 ± 0.76a
Corn syrup (48%)	7.59 ± 0.48	7.02 ± 0.89a	5.97 ± 0.69a	6.67 ± 0.65a	6.52 ± 0.81a	6.76 ± 0.81a
F-Value	NS	*	*	*	*	*
S.Em. ±	-	0.24	0.31	0.24	0.27	0.26
CD	-	0.47	0.61	0.47	0.53	0.52

Values expressed as Mean ± SD. * Significant ($P < 0.05$), NS-non significant.
Values with different superscripts within same column differ significantly.

Table 4: Sensory scores of protein bars prepared with combination of sweeteners

Sweeteners #	Appearance	Texture	Colour	Flavour	Taste	Overall acceptability
Jaggery:Corn syrup = 50:50	7.83 ± 0.37	6.36 ± 1.04	7.48 ± 0.46	7.51 ± 0.74	7.20 ± 0.94a	7.42 ± 0.85a
Jaggery:Corn syrup = 60:40	7.74 ± 0.74	7.00 ± 1.51	7.55 ± 0.64	7.84 ± 0.83	8.01 ± 0.59b	8.07 ± 0.67b
Jaggery:Corn syrup = 40:60	7.69 ± 0.60	6.45 ± 1.31	7.45 ± 0.57	7.50 ± 0.84	7.43 ± 0.81a	7.28 ± 1.09a
F-value	NS	NS	NS	NS	*	*
S.Em. ±	0.32	1.48	0.18	1.19	0.24	0.28
CD	-	-	-	-	0.49	0.55

- Sweeteners constituted 48 percent of the bar formulation.
Values expressed as Mean ± SD**.** * Significant ($P< 0.05$), NS-non significant.
Values with different superscripts within same column differ significantly.

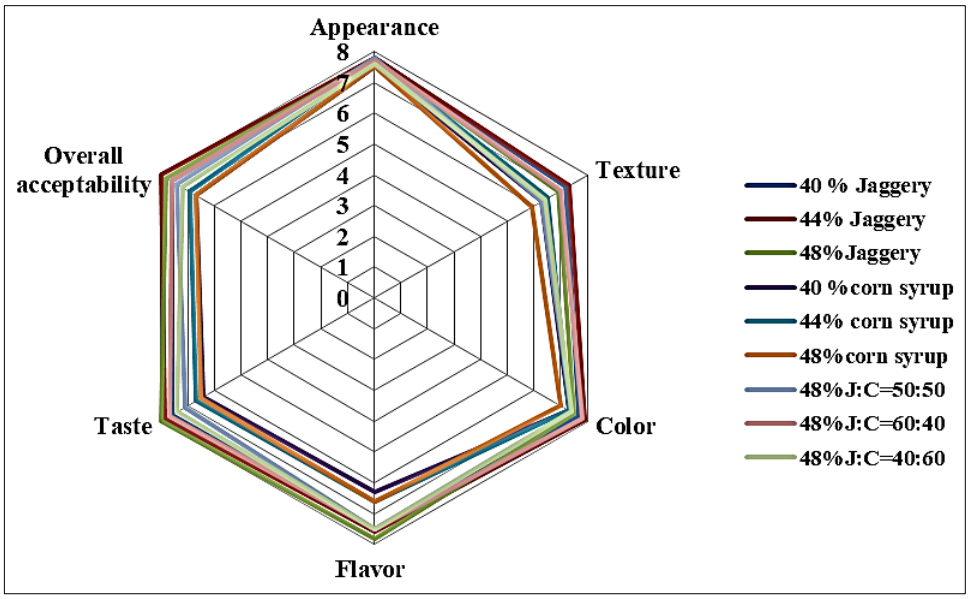

Fig 4: Spider web for sensory analysis of protein bars on a 9-point Hedonic scale

4. Discussion

Sensory analysis results revealed that all the protein bar formulations with jaggery were superior in terms of all the sensory attributes compared to corn syrup. From overall acceptability scores it was observed that protein bars with corn syrup were less liked by the panellists, which might be because of their hard texture as the bars became harder eventually following the day of production. The mechanisms of bar hardening with corn syrup were reported in previous studies also. McMahon *et al*. (2009) [13] reported that after 7d storage at 32 °C, significant differences in bar hardness were noticed in high protein bars prepared with whey protein isolate and high fructose corn syrup and the bars were significantly hardest. When sugar/polyol syrups were mixed with protein powder, during and after mixing there will be transfer of water molecules from the syrup to the protein powder. This change takes place as water migrates from the higher a_w high fructose corn syrup to the lower a_w powders, where the syrups will eventually lose their ability to act as plasticizers and the bars will harden as a function of the moisture migration (Li *et al.* 2008; Hazen, 2010) [7, 9].

In the present study the protein bars prepared with jaggery alone as a sweetener remained softer compared to corn syrup, which may be due to lower a_w of jaggery and also may be due to lesser rate of water migration from jaggery to the protein powder.

Among the three combinations of sweeteners the product prepared with 60:40 = J:C combination obtained significantly higher scores for taste and overall acceptability when compared to other two combinations. Moderate hardening was observed in these bars prepared with combinations of sweeteners. In multigrain fibre and protein enriched composite bars prepared by Mathur *et al.* (2020) [12] with three different concentrations (40%, 44%, and 48%) in each of cane sugar, honey, and jaggery; bar prepared with 44 percent jaggery was adjudged best in terms of taste, texture, and overall acceptability.

Protein bars with 44 percent jaggery obtained highest total mean sensory score and acceptability index. In a study by Ansari *et al.* (2020) [2] it was reported that high protein energy bars prepared with 50 percent jaggery along with other ingredients (15% flax seeds, 15% watermelon seeds, 20% bengal gram) had highest overall acceptability score of 8.5. In another study results of nutri bars formulated using different proportion of jaggery and dry raw materials (Groundnut, finger millet flour, sprouted moth bean flour, sprouted bengal gram flour, carrot powder, beetroot powder, sesame etc.) revealed that nutri bar prepared using 50 percent jaggery and 50 percent other ingredients, had best quality (Ghatge *et al.* 2020) [6].

5. Conclusion

The formulation and process for preparation of protein bars from different sweetener source was standardized. Evaluation of sensory acceptability of protein bar showed that formulations with jaggery were superior in terms of all the sensory attributes compared to corn syrup alone and combination of jaggery and corn syrup.

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