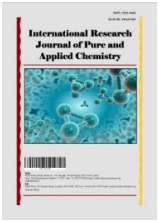

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Technology for Manufacture of Dietetic Functional *Basundi*

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Authors' contributions

This work was carried out in collaboration among all authors. Author GAJ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors PAM and MJM managed the analyses of the study. Author PHG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Dietetic functional *Basundi* was manufactured by employing low fat milk (1.5 per cent) with WPC and blend of stabilizer as fat replacer; Sucrose was replaced with intense sweetener sucralose and the bulk of sucrose was replaced with different combination of blend of polydextrose, maltodextrin and sorbitol as bulking ingredients. Replacement of sucrose with intense sweetener and combination of bulking ingredients did not affect compositional and physico-chemical attributes however a non-significant rise in 5'HMF content was observed with increase in ploydextrose content in the bulking ingredients' blend. Viscosity followed the similar trend that was noted for 5'HMF. In sensory attributes body and texture and flavour score had significant impact of replacement of sucrose. Polydextrose in the blend when increased to more than 9.0 percent, it increased the body and texture and flavour score significantly, however such increase was non-significant for body and texture score, while flavour score decreased non-significantly. Overall acceptability score followed the similar trend observed for body and texture score. Polydextrose: Maltodextrin: Sorbitol in the proportion of 12:01:03 was considered best because of creamier body with polydextrose and sorbitol being more laxative at increased proportions.

Keywords: Basundi; sucralose; polydextrose; sorbitol; WPC; sodium alginate; carrageenan; dietetic.

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1. INTRODUCTION

India produces approximately 187.7 million tons of milk annually. Around 50% milk produced is converted to traditional Indian dairy products [1]. *Basundi* is a delicious heat desiccated concentrated sweet meat, very much popular in western part of India. It is also used as base material for sweets like *Ras Malai* and *Angur Basundi*. *Basundi* contains all the solids of milk in an appropriate concentration and contains additional sugar, spices and dry fruits. *Basundi* is having sweetish caramel pleasant aroma, with light to medium brown color, thick body and creamy consistency with or without soft flaky texture that are uniformly suspended throughout the product. *Basundi* contains approximately 11% fat and 12 to 15% cane sugar and approximately 210 Kcal [2]. In India, 69.1 million people suffer with diabetes and are further growing to be the second highest number of cases of Diabetes Mellitus (DM) in the world. In India, the prevalence of DM ranges from 5– 17% [3]. Health conscious people are also finding an alternative to low calorie dietetic foods that contains less fat and sugar alternatives. Goel and Pagote (2010) [4] reported use of non-conventional sweeteners in production of *Basundi*. They used aspartame, sucralose and stevia as sweetener. It was found that replacements up to 100%, 50% and 20% of sugar levels were possible using sucralose, aspartame and stevia, respectively Sucralose was found to be the best non-conventional sweetener compared to aspartame and acesulfame-k for the production of sugar free Rabri [5]. Gaikwad et al. (2016) [6] manufactured dried crushed date fruit containing *Basundi.* Such *Basundi* was containing 6% date fruit crush, and had 9.55% fat, 9.16% protein and 47.08% total solids. It was having a delicious sweet taste. A "bottle gourd *Basundi*" was manufactured using cow milk, Sugar @ 10% and bottle gourd pulp @ 10%. It had 60.30 % moisture and protein fat and sucrose were 16.81%, 9.23%, and 32.35% respectively [7]. Gite et al. (2017) [8] prepared *Basundi* by using different levels of custard apple pulp; *Basundi* blended with 30% of custard apple pulp had the highest sensory score and was having 53.90 % moisture, 1.56 % ash, 10.85 % crude fat, 7.5 % crude protein, 26.19 % carbohydrate, 46.11 % total solid and 0.42 % acidity. According to the WHO, India ranks among top 10 obese nations of the world and it has been reported that 170 millions of urban Indians are seriously obese [9]. Present investigation was carried out to evaluate the possibilities of reducing calories by reducing fat by employing food gums and whey protein as fat replacer as per Gokhale et al. (2018) [10] and total sucrose was replaced by employing intense sweetener sucralose in dietetic *Basundi*.

2. MATERIALS AND METHODS

Fresh mix milk was procured from Vidya dairy AAU, Anand and skim milk was separated in an open discharge 'Alfa Laval' power driven mechanical cream separator. Whey Protein Concentrate (WPC-70): Buffalo milk WPC-70 obtained from M/S. Mahaan Protein Ltd., Kosikalan, Uttar Pradesh. Commercial grade white crystalline sugar purchased from local market has been used in control sample. Na-alginate and *Carrageenan* based food gum from M/S. S. Square & Co., Gwalior, Polydextrose (Stalite III) from M/S. Tate and Lyle, US, maltodextrin from M/S. Riddhi Siddhi Biols Ltd., Ahmedabad, Sorbitol (70%) from M/S. Loba Chemicals Limited, Sucralose was obtained from Ensign Health Care Pvt. Limited, Pune was procured.

2.1 Preparation of *Basundi*

Basundi was prepared as per the method developed by Patel and Upadhyay (2003 b, c) [2, 11-12]. A low fat *Basundi* was prepared as per Gokhale et al., (2018) [10] and sucrose (15.0 % in control) quantity (Patel and Upadhyay, 2003 a) [11] was replaced with different combination levels of bulking ingredients and intense sweetener sucralose (Table 1). On the basis of preliminary trials, sorbitol, polydextrose and maltodextrin as bulking ingredients were selected to replace the bulk of sucrose with sucralose as intense sweetener. The bulking ingredients have different calories and have different range of sweetness. Thus, selection was made on the basis of its sweetness component and minimum calories. Polydextrose provides only 1.0 kcal and have blend taste while sorbitol provides 2.6 kcal and is 60% sweeter than sucrose. Maltodextrin was selected on the basis of its viscosity modifying properties and cost too. However as it provides similar calories compared to sucrose, its level was kept minimum and constant so as to achieve calorie reduction in the product. Other physico-chemical properties of these bulking ingredients vary and to exploit their intrinsic properties in *Basundi,* it was necessary to use them in combination.

Table 1. Combination of bulking ingredients (%) studied in development of dietetic *Basundi*

Bulking ingredient level	Polydextrose (% w/w)	Maltodextrin (% w/w)	Sorbitol (% w/w)	Sucralose[1] (g / 100 kg *Basundi*)
T1	5.0	1.0	13.0	14.16
T2	7.0	1.0	10.0	16.66
T3	9.0	1.0	7.0	19.16
T4	10.0	1.0	6.0	20.00
T5	11.0	1.0	4.0	21.66
T6	12.0	1.0	3.0	22.50

[1] *Rate of addition of sweetener is calculated on the basis of sweetness contributed by sweet component - sorbitol - present in the blend which is 0.5 x sweeter than sucrose*

The sweetness in the final product was adjusted taking the sweetness intensities of sucralose, polydextrose, maltodextrin and sorbitol into account.

2.2 Analysis of Milk and dietetic *Basundi*

Analysis of milk and dietetic *Basundi* was carried out by standard methods. Fat content of milk samples were determined by Gerber method [13]. Fat and total solids content of dietetic *Basundi* was estimated gravimetrically using Mojonnier milk tester, Model-D as per the standard procedure [14]. SNF content of milk samples was determined by using Zeal lactometer [15]. The ash, lactose and sucrose content of milk and dietetic *Basundi* samples were determined as per Bureau of Indian Standard [16]. Protein content as total nitrogen of milk and dietetic *Basundi* were determined by Semi-Microkjeldahl method [17-18]. Percent lactic acid in all the samples was determined as % lactic acid (LA) as per IS 1479, Part II 1961[17]. The pH of milk and dietetic *Basundi* samples was measured at 25^{o}C by potentiometric method using Systronics Digital pH meter. Specific gravity of dietetic *Basundi* samples was determined according to the method described by Ling (1956) [19]. The viscosity of dietetic *Basundi* samples was determined using 'Haake' viscosimeter (Model VT-550, M/S. Gebr, HAAKE GmbH, Germany). The equipment was standardized to system No.1 MV-DIN with a f factor of 61.4 Pa/N-cm and M factor of 1.29 (min/s) using speed level 10 (i.e. 500 rpm). The values of viscosity (η) recorded were in mPa.s. The quantitative method presented by Keeney and Bassette (1959) [20] for quantifying 5-HMF by spectrophotometric measurement of the 2-thio barbituric acid (TBA) reaction product was used to assess the extent of browning in milk and dietetic *Basundi* samples. Free Fatty acids (FFA) content of milk/ dietetic *Basundi* samples was determined by the method suggested by Deeth and Fitz-Gerald (1976) [21].

2.3 Sensory Evaluation of Dietetic *Basundi*

Dietetic *Basundi* after preparation was cooled below 5^{o}C and then evaluated for its sensory characteristics by a panel of 8 judges selected from Dairy Technology department staff of the college. A 100-point descriptive scale was used for sensory attributes like Flavor, Body & Texture and Color & Appearance [22].

3. RESULTS AND DISCUSSION

Basundi was manufactured as per the standardized procedure given by Patel and Upadhyay (2003 b, c) [11-12] and the use of ingredients for the low fat *Basundi* and dietetic *Basundi* remained same as suggested by Gokhale et al. (2018) [10]. For manufacture of low fat *Basundi*, milk having 1.5 % fat added with WPC-70 @ 3.0 (%, w/w) and food gum blend (sodium alginate + carageenan, 1:1) @ 0.1 (%, w/w) as fat replacers was employed and sucrose was replaced by use of different levels of combinations of bulking ingredients and calculated quantity of sucralose was added after reaching to desired concentration level. Dietetic *Basundi* was cooled to < 10^{o}C and stored under refrigeration temperature till analyzed.

3.1 Effect of Addition of Bulking Ingredients and Sucralose on Compositional Attributes of Dietetic *Basundi*

In the manufacture of dietetic *Basundi*, concentration was discontinued at appropriate stage so as to have viscosity in the desirable range It was necessary to control the viscosity as in the formulation of dietetic *Basundi*, food gums, WPC-70, polydextrose and maltodextrin were present and all this ingredients have varied effect on viscosity. In the preliminary trials, apparent viscosity was adjudged and then it was decided

to control the concentration ratio to around 2.1 to 2.2 for final product.

Effect of addition of bulking ingredients and sucralose on compositional attributes is depicted in Table 2. It could be seen from the tabulated data that all the compositional attributes like fat, protein, lactose, ash, total solids and yield though varied, the variation observed could not impart statistically significant (P≤0.05) effect on these compositional attributes. Such non-significant minor variations could be ascribed to the minor variation observed in total solids content of experimental samples. This was obvious because the concentration process was controlled on the basis of apparent viscosity and concentration ratio. Yield content had also minor non-significant variations and it ranged from 4.60 to 4.75 kg /10 kg milk. Goel and Pagote (2010) [4] reported higher fat (12.02%) and total solids (46.18%) content and lower values for protein (9.06) and ash (1.52) content than observed in present study for *Basundi* prepared by employing sucralose as sweetener along with maltodextrin only as bulking ingredients.

3.2 Effect of Addition of Bulking Ingredients and Sucralose on the Physico-chemical Attributes of Dietetic *Basundi*

Physico-chemical properties have the key role to play in deciding the overall acceptability of the product. It can give the idea regarding the fate of newly formulated or developed product in the market and also help in predicting shelf life of the formulated product. Data presented in the Table 3 shows the effect of addition of combination of bulking ingredients on physic chemical properties like, acidity (%LA), pH, FFA, Hydroxymethylfurfural (HMF), water activity and viscosity.

Acidity and pH of the experimental samples varied but such variation was non-significant (P≤0.05). Similar trend was observed for FFA, HMF and water activity and such non-significant (P≤0.05) variation could be due to minor non-significant variation observed in fat and total solids content (Table 2). A non-significant increase in water activity was ascribed to decrease in sorbitol content. Similar trend was reported by Raju and Dharmpal (2011) [23] in the artificially sweetened misti dahi.

Viscosity of the dietetic *Basundi* samples was significantly (P≤0.05) affected by replacement of bulk of sucrose with bulking ingredients. Sample T1 had the lowest viscosity values of 55.52±1.26 (mPa.s at 18^0C) and it increased and became highest to 58.92±1.34 (mPa.s at 18^0C) in T6 sample. Such significant (P≤0.05) increase was noted only at the T4 level. Similarly samples T5 and T6 had significantly (P≤0.05) higher viscosity as compared to T2 sample. Though increase in viscosity of dietetic *Basundi* samples T1, T2 and T3 was observed, such increase was statistically non-significant. Higher level of sorbitol could not bring about significant effect on viscosity but incremental level of polydextrose in the blend of bulking ingredients imparted significant (P≤0.05) effect on viscosity.

Table 2. Influence of varying levels of bulking ingredients and sucralose on the compositional attributes (%) and yield (kg/10 kg milk) of dietetic *Basundi*

Treatments (Polydextrose + Maltodextrin + Sorbitol) % w/w + Sucralose, g/100kg	Compositional attributes (%) and yield of dietetic *Basundi*					
	Fat	Protein	Lactose	Ash	Total solids	Yield (kg/10 kg milk)
T1 (5+1+13+14.16)	3.10±0.18	12.35±0.10	10.80±0.62	1.65±0.12	39.15±1.21	4.75±0.07
T2 (7+1+10+16.66)	3.15±0.12	12.40±0.12	10.85±0.59	1.63±0.14	39.20±1.10	4.70±0.08
T3 (9+1+7+19.16)	3.15±0.16	12.40±0.14	10.80±0.61	1.65±0.13	39.24±1.03	4.70±0.06
T4 (10+1+6+20)	3.05±0.10	12.45±0.13	10.90±0.62	1.64±0.16	39.18±1.08	4.65±0.07
T5 (11+1+4+21.66)	3.10±0.12	12.45±0.12	10.85±0.64	1.64±0.12	39.28±1.05	4.65±0.06
T6 (12+1+3+22.50)	3.10±0.10	12.40±0.10	10.90±0.60	1.66±0.11	39.33±1.00	4.60±0.08
S. Em.	0.082	0.065	0.029	0.06	0.596	0.037
C.D. (0.05)	NS	NS	NS	NS	NS	NS
C.V. %	3.56	5.36	1.68	4.28	2.96	2.56

1. *Each observation is a mean ± SD of four replicate experiment (n=4)*
2. *Each mean is compared using CD values obtained from statistical analysis of data*
3. *Numbers in each labeled data superscripted with the same alphabet in the same column are not significantly different (P≤0.05)*

Table 3. Influence of varying levels of bulking ingredients and sucralose on the physico-chemical properties of dietetic *Basundi*

Treatments (Polydextrose + Maltodextrin + Sorbitol) % w/w + Sucralose, g/100kg	Physico-chemical properties of dietetic *Basundi*					
	Acidity % LA	pH	FFA µeq/ml	HMF µmol/l	Water activity (aw) (25^{O}C)	Viscosity m Pa.s (18^{O}C)
T1 (5+1+13+14.16)	0.36±0.010	6.54±0.013	0.62±0.006	10.49±0.16	0.96±0.011	55.52±1.26^{a}
T2 (7+1+10+16.66)	0.36±0.012	6.54±0.014	0.61±0.005	10.52±0.015	0.96±0.012	56.81±1.31^{a}
T3 (9+1+7+19.16)	0.36±0.009	6.55±0.013	0.62±0.006	10.54±0.013	0.96±0.011	56.93±1.28^{a}
T4 (10+1+6+20)	0.36±0.012	6.54±0.013	0.61±0.006	10.72±0.014	0.97±0.012	57.84±1.29^{b}
T5 (11+1+4+21.66)	0.37±0.013	6.53±0.015	0.62±0.005	10.72±0.012	0.97±0.010	58.86±1.32^{b}
T6 (12+1+3+22.50)	0.37±0.009	6.54±0.011	0.62±0.006	10.76±0.011	0.97±0.010	58.92±1.34^{b}
S. Em.	0.0051	0.0065	0.0032	0.065	0.0055	0.645
C.D. (0.05)	NS	NS	NS	NS	NS	1.93
C.V. %	1.09	2.34	3.56	1.29	1.02	5.36

1. *Each observation is a mean ± SD of four replicate experiment (n=4)*
2. *Each mean is compared using CD values obtained from statistical analysis of data.*
3. *Numbers in each labeled data superscripted with the same alphabet in the same column are not significantly different (P≤0.05)*

Rao and Pagote (2018) [5] has reported marginally higher total solids content (40.91%) and lower protein content (11.71%) for sugar free Rabri but have used 34.1g/100 Kg sucralose which is very much higher than observed in present study. Similarly ash content and acidity was higher and pH was lower compared to the product developed in the present study.

3.3 Effect of Addition of Bulking Ingredients and Sucralose on Sensory Attributes of Dietetic *Basundi*

Sensory attributes of any food and dairy products has profound effect on its general acceptance. It is necessary to evaluate the formulated product by a trained panel of judges for its sensory attributes. In the present study, the samples of dietetic *Basundi* was given to the trained panel of judges and scores obtained are tabulated in the Table 4 and Fig. 1.

The colour and appearance score had non-significant (P≤0.05) increase from 11.63±0.23 in T1 to 12.32±0.21 in T4. It had mixed trend of increase and decrease in score for this attribute. Such variation could not impart significant (P≤0.05) effect on colour and appearance attribute.

The body and texture score as depicted in Table 4.26 showed the significant (P≤0.05) rise in score and it increased from 30.15±0.59 in T1 to 32.93±0.58 in T5. Sample T3 received significantly (P≤0.05) lower score as compared to T5, however it remained statistically at par with scores obtained in sample T4 and T6. The observed trend could be due to variation observed in viscosity as shown in Table 3 which might have resulted in slightly more glossy and shiny appearance as compared to those samples having lower viscosity.

Similarly flavour score obtained was significantly (P≤0.05) affected by substitution of bulk of sucrose with combination of bulking ingredients. . It varied from 39.15±1.03 in T3 sample being lowest to 40.16±1.09 in T4 sample being the highest. Samples T1, T2 and T3 had received significantly (P≤0.05) lower scores and were statistically identical. T4 sample received significantly (P≤0.05) higher score which decreased in sample T5 and increased marginally in T6. Such decrease and increase was marginal and hence sample T4, T5 and T6 remained statistically at par.

Generally bulking ingredients should not impart any flavour which could become objectionable to the dietetic product. In the study, the care was taken in selection of the bulking ingredient which will not directly contribute to the flavour; however its interaction products might have contributed towards the observed results.

Table 4. Influence of varying levels of bulking ingredients and sucralose on the sensory properties of dietetic *Basundi*

Treatments (Polydextrose + Maltodextrin + Sorbitol) % w/w + Sucralose, g/100kg	Sensory characteristics of dietetic *Basundi*			
	Colour & appearance (out of 15)	Body & texture (OUT OF 35)	Flavour (out of 45)	Total score (out of 100)
T1 (5+1+13+14.16)	11.63±0.23	30.15±0.59[a]	39.35±1.05[a]	86.13±1.64[a]
T2 (7+1+10+16.66)	12.06±0.25	30.26±0.65[a]	39.32±1.08[a]	86.64±1.58[a]
T3 (9+1+7+19.16)	12.02±0.26	31.04±0.62[a]	39.15±1.03[a]	87.71±1.72[ab]
T4 (10+1+6+20)	12.32±0.21	32.12±0.64[ab]	40.16±1.09[b]	89.60±1.62[b]
T5 (11+1+4+21.66)	12.18±0.24	32.93±0.58[b]	39.82±1.06[b]	89.93±1.59[b]
T6 (12+1+3+22.50)	12.22±0.20	32.76±0.61[ab]	40.02±1.04[b]	90.00±1.61[b]
S. Em.	0.116	0.324	0.524	0.823
C.D. (0.05)	NS	1.83	0.36	2.18
C.V. %	2.38	4.62	2.95	4.81

1. *Each observation is a mean ± SD of four replicate experiment (n=4)*
2. *Each mean is compared using CD values obtained from statistical analysis of data.*
3. *Numbers in each labeled data superscripted with the same alphabet in the same column are not significantly different (P≤0.05)*

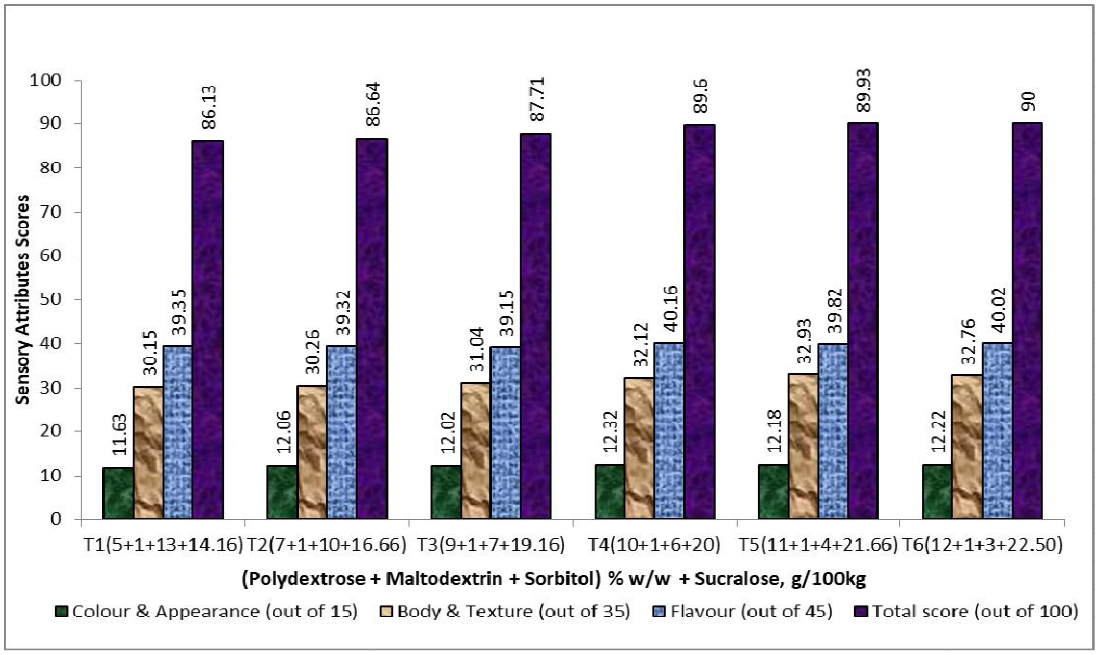

Fig. 1. Influence of varying levels of bulking ingredients and intense sweetener on the sensory properties of dietetic *Basundi*

Total score is the total of the scores obtained in other three attributes and thus, is the combined effect of other three attributes in sensory evaluation. Total score increased at each level and varied from 86.13±1.64 being the lowest obtained for sample T1, to 90.00±1.61 obtained for sample T6, which was significantly (P≤0.05) higher and remained highest among all the samples under study. Total score received by sample T1, remained statistically at par with scores obtained by samples T2 and T3. Similar trend was noted for samples T4, T5 and T6 which also had statistically identical scores. Samples T5 and T6 received higher scores and were significantly higher as compared to T3 sample. Polydextrose is claimed to retain creaminess and impart the qualities of smoothness, by improving texture and mouth-feel in low calorie ice cream and frozen desserts [24]. Same could have turned true and is being

reflected in body and texture score and total score which gradually rose up to T6 level. Cadena and Bolini (2011) [25] found that calorie-reduced ice creams sweetened with sorbitol and sucralose (with a sugar reduction of 3.4%) were most accepted compared with other "light" vanilla ice creams or ice cream with a minimum reduction of 25% of the total energy, sugar, or lipid.

4. CONCLUSION

Complete replacement of sucrose by bulking ingredients and intense sweetener sucralose in dietetic *Basundi* had non-significant (P≤0.05) impact on compositional attributes. This was due to the fact that composition of milk and level of fat replacers remained similar in all six different levels under study. Only sucrose was replaced by combination of bulking ingredients with utmost care in deciding combination levels. This could have helped in controlling the physico-chemical qualities of the product. The only impact was on viscosity, that increased significantly (P≤0.05) with substantial increase in amount of polydextrose in the blend. Such effect on viscosity was not witnessed when higher level of sorbitol was present. Thus, increased viscosity in experimental samples had resulted in significant (P≤0.05) effect on sensory properties except colour and appearance score. Body and texture score increased up to *T5* level and then decreased marginally in T6 level. Similar trend was observed for flavour score, and it increased up to T4 level and later it decreased marginally in T5 level and once again it increased marginally in T6 level but score obtained for flavour in T6 level remained lower than T4 level. Total score was also significantly (P≤0.05) affected and had followed similar increasing trend observed in body and texture score.

Thus in the dietetic *Basundi* manufacture, milk used was having 1.5 % fat added with WPC-70 @ 3.0 (%, w/w) and food gum blend (sodium alginate + carageenan, 1:1) @ 0.1 (%, w/w) as fat replacers and the bulk of the sucrose can be replaced by combination containing polydextrose @ 12.0 % w/w, maltodextrin @ 1.0 % w/w, sorbitol @ 3 % w/w and sucralose @ 21.66 g/100 kg *Basundi* was considered most suitable bulking ingredient combination and intense sweetener respectively.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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