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Development of technology for manufacture of low fat protein enriched functional *Basundi*

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Abstract
Low fat protein enriched *Basundi* was prepared by employing four different levels of fat in milk, i.e 4.5 % fat in milk (control, T1) and three reduced levels of fat in milk (3.0 (T2), 1.5 (T3) and 0.2% (T4) fat). Na alginate and carrageenan (1:1) @ 0.0 (T1), 0.20 (T2), 0.30 (T3) and 0.40 (T4) % was added in partially concentrated milk along with sugar. Protein, ash, SNF and sucrose content reduced significantly ($p \leq 0.05$) in low fat samples but they remained statistically at par in these compositional values. Total solids, FFA and 5-HMF decreased significantly at each substitution level. Sensorily sample T2, having 3.0% fat in milk with 0.20% food gums was adjudged best. To explore the possibility of further reduction of fat in *Basundi*, whey protein concentrate (WPC-70), in place of food gums was added as fat replacer, at the equivalent rate of substitution of fat in milk i.e. 1.5, 3.0 and 4.5%. *Basundi* had significant reduction in fat, sucrose and total solids content; significant increase in protein (36%), lactose (5.7%) and SNF (20%) content was observed. Acidity, pH, water activity and viscosity had non-significant variation. FFA and 5-HMF content decreased significantly in low fat *Basundi*. Yield increased in low fat *Basundi* samples. Without affecting sensory properties, further reduction up to 1.5% level of fat in milk was possible by incorporation of WPC-70 @ 3.0%. Thus 66% reduction in fat and 38.5% increase in protein content of *Basundi* was possible.

Keywords: *Basundi*, whey protein concentrate, sodium alginate, carrageenan, low fat, protein

Introduction
India produces approximately 132.4 million tons of milk annually. Around 50% milk produced is converted to traditional Indian dairy products (Prasad *et al.*, 2015) [25]. *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*, *Angur Basundi*. *Basundi* contains all the solids of milk in an appropriate concentration plus additional sugar and dry fruits. Dried crushed date fruit containing *Basundi* was manufactured by Giakwad (2016). 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 (Bhutkar *et al.*, 2015) [2]. *Basundi* contains approximately 11% fat and 12 to 15% cane sugar and approximately 210 Kcal. According to the WHO, the obesity epidemic is increasing faster in the developing countries than in the developed world. Paradoxically, India is one of the nation's facing an obesity crisis. India ranks among top 10 obese nations of the world and it has been reported that 170 millions of urban Indians are seriously obese (Mohan *et al*, 2013) [18]. Increased milk and milk products' consumption lead to intake of more total calories from saturated fats. But other side of the story depicts that foods should be low in calories by reducing saturated fat and cholesterol while providing nutrients like protein, calcium, magnesium and vitamins. Present investigation was carried out to evaluate the possibilities of reducing fat by employing food gums and whey protein as fat replacer in low fat *Basundi*.

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. Na-alginate and *Carrageenan* based food gum was procured from M/S. S. Square & Co., Gwalior.

Manufacture of *Basundi*

Basundi was manufactured as per the method developed by Patel and Upadhyay (2003 b, c) [22, 23]. After preliminary study, four levels of fat in the milk: 4.5 % (T1), 3.0 % (T2), 1.5 % (T3) and 0.2 % (T4) were decided for the experimentation. Control (4.5 % fat and 9.0 % SNF, T1) and low fat milks (T2 to T4) were concentrated in open pan till the required concentration of the milk was achieved. In each treatment, 10 kg of milk was taken and processed in to *Basundi*. Sugar was added @ 6% of milk quantity (Patel and Upadhyay 2003a) [21] at appropriate stage of concentration. *Basundi* was prepared employing combination of food gums combination of Na-alginate and carrageenan based hydrocolloids in 1:1 proportion and rate of addition was 0.2% in T1, 0.3% in T2 and 0.4% in T4 sample. Similarly whey protein concentrate (WPC-70), was added @ 1.5% in T1, 3.0% in T2 and 4.5% in T4 sample.

Analysis of Milk and *Basundi*

Analysis of milk and Basundi was carried out by standard methods. Fat content of milk samples were determined by Gerber method (IS: 1224, 1977). Fat and total solids content of *Basundi* was estimated gravimetrically using Mojonnier milk tester, Model-D as per the standard procedure (Laboratory Manual, 1959). SNF content of milk samples was determined by using Zeal lactometer (IS: 10083, 1982). The ash, lactose and sucrose content of milk and *Basundi* samples were determined as per Bureau of Indian Standard (IS: SP 18, Part XI, 1981). Protein content as total nitrogen of milk and *Basundi* were determined by Semi-Microkjeldahl method (IS: 1479- Part II 1961). Percent lactic acid in all the samples was determined as % lactic acid (LA) as per IS 1479, Part II 1960. The pH of milk and *Basundi* samples was measured at 25°C by potentiometric method using Systronics Digital pH meter. Specific gravity of *Basundi* samples was determined according to the method described by Ling (1956) [15]. The viscosity of *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) [12] 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 *Basundi* samples. Free Fatty acids (FFA) content of milk/*Basundi* samples was determined by the method suggested by Deeth and Fitz-Gerald (1976) [3].

Sensory evaluation of *Basundi*

Basundi after manufacture was cooled below 5°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 (IS: 6273, 1971) [10].

Results and Discussion

Basundi was manufactured as per the standardized procedure given by Patel and Upadhyay (2003 b, c) [22, 23]. It was decided to reduce the calorie content of the *Basundi* by reducing the milk fat content. Fat content of *Basundi* was reduced at different levels, with addition of food gums and WPC-70 separately. Some more than twenty trials were taken by addition of food gums combination and WPC-70 at different levels, for deciding the optimum viscosity and respective total solids content required to simulate viscosity of reduced fat *Basundi* samples with that of control sample. Accordingly apparent viscosity and respective total solids were controlled and was measured by abbe refractometer to decide discontinuation of concentration in the present experiment.

Selection of food gums as fat replacer

It was noted during preliminary trials that reducing fat content leads to increase in concentration ratio so as to achieve similar total solids present in control *Basundi* recipe. As a result, the product became thick bodied, chalky, lacking in typical flavour of fat and has partially destabilized appearance at this elevated concentration ratio. Hence, it was decided to add such component which can mimic the role of fat and helps in attaining viscosity similar to that of control (prepared from standardized milk) *Basundi*. Carrageenan is a hydrocolloid that finds maximum application in dairy desserts like puddings, milk shakes, ice-cream and chocolate milk because of its ability to form gels in milk at much lower concentrations compared to any other gelling agent (Puvanenthiran *et al.* 2003; Verbeken *et al.* 2004) [26, 28]. In the present study it was decided to add food gums as fat replacer. Screening of food gums and their rate was carried out in the preliminary trials on the basis of mouth feel, bland flavour and stability of the product during storage. Sodium alginate and carrageenan based food gums blend was chosen because of their excellent properties in relation to viscosity modification and ready availability in the local market. The rate of addition of food gums combination was decided on the basis of preliminary trials taken for low fat *Basundi.* The experiment was replicated four times employing sodium alginate and carrageenan based food gum blend in the ratio of 1:1 @ 0.0 (T1), 0.20 (T2), 0.30 (T3) and 0.40 (T4) per cent in formulation (Table 1). The *Basundi* thus prepared was subjected to evaluation for its compositional characteristics, physico-chemical properties and sensory attributes.

Table 1: Influence of substitution of milk fat by food gums on average proximate composition of *Basundi*

Level of milk fat + food gum blend in milk (%, w/w)	Compositional Attributes (%) of *Basundi*						
	Fat	Protein	Lactose	Ash	SNF	Sucrose	Total Solids
T1 (4.5 + 0.0)	10.60±0.49^{a}	9.15±0.06^{a}	10.30±0.07^{a}	1.64±0.03^{a}	21.25±0.38^{a}	14.00±0.36^{a}	45.85±2.10^{a}
T2 (3.0 + 0.2)	6.70±0.35^{b}	8.80±0.05^{b}	9.90±0.09^{b}	1.56±0.02^{b}	20.36±0.29^{b}	13.50±0.40^{b}	40.56±1.96^{b}
T3 (1.5 + 0.3)	3.30±0.51^{c}	8.60±0.07^{b}	9.60±0.08^{bc}	1.54±0.04^{b}	20.05±0.35^{b}	13.40±0.28^{b}	36.75±2.21^{c}
T4 (0.2 + 0.4)	0.45±0.11^{d}	8.53±0.06^{b}	9.50±0.11^{c}	1.53±0.01^{b}	19.75±0.12^{b}	13.30±0.32^{b}	33.50±1.95^{d}

Each observation is a mean ± SD of four replicate experiment (n=4)

Each mean is compared using CD values obtained from statistical analysis of data.

Numbers in each labeled data superscripted with the same alphabet in the same column are not significantly different ($p \leq 0.05$)

Effect of substitution of fat by food gums combination on compositional attributes of *Basundi*

Addition of combination of food gums were carried out at partial concentration stage (i.e. at ~ 1.8 -1.9 x concentration stage). In low fat *Basundi* samples, concentration process was discontinued upon achieving similar apparent viscosity to that of control sample. This helped in simulating body and texture of the low fat *Basundi* samples with that of control sample (T1).

The data depicted in the Table 1 shows the effect of substitution of milk fat by incorporation of food gums on average compositional attributes of experimental *Basundi* samples.

As per the aim of experiment, the mean values for fat content reduced significantly ($p \leq 0.05$) at each treatment level. In absence of incorporation of any other source of fat, reduction in fat and thereby reduction of calories in experimental *Basundi* samples was achieved.

Protein, ash, SNF and sucrose content also reduced significantly ($p \leq 0.05$) in all the low fat *Basundi* samples as compared to control (T1). Low fat *Basundi* samples (T2, T3 and T4) had minor non-significant reduction in their values for protein, ash, SNF and sucrose content but they were statistically at par. The T4 sample, which had the lowest fat and highest level of food gums blend, had the lowest protein, ash, SNF and sucrose content. Thus low fat *Basundi* samples statistically ($p \leq 0.05$) remained alike among themselves. Significant reduction in protein, ash, SNF and sucrose observed in present study could be due to attainment of lower ration of concentration in experimental *Basundi* samples. Gaikwad and Hembade (2011) [6] reported similar trend for reduction of protein, sucrose and ash content affected by ration of concentration.

The effect of substitution of fat by incorporation of food gums showed statistically significant ($p \leq 0.05$) reduction in total solids content in experimental *Basundi* samples. It differed significantly in all experimental samples compared to control sample (T1), that had highest total solids content of 45.85 % followed by low fat *Basundi* sample T2 that had significantly higher (40.56 %) total solids as compared to other two low fat *Basundi* samples T3 and T4. Sample T4 had lowest total solids content of 33.50 % among all the *Basundi* samples. Reduction in fat content led to reduction in total solids content of milk and as no other source of fat and / or any other milk solids was incorporated, the effect was obvious. In addition to this view, it could be due to reaching of the apparent viscosity earlier as compared to control (T1) sample of *Basundi* in presence of combination of food gums which resulted in lower concentration ratio in low fat *Basundi* samples. Similar trend has been reported by Naresh and Shailaja (2006) [19] in low fat ice cream containing different blend of stabilizers.

Effect of substitution of milk fat by food gums combination on physico-chemical attributes and Yield of *Basundi*

The decrease in milk fat level and increase in food gums addition in *Basundi* did not have any significant ($P \leq 0.05$) effect on the acidity and pH values (Table 2). Water activity of the experimental *Basundi* samples decreased non-significantly from 0.98±0.028 (a_w at 25°C) in T1 and T2 samples to 0.97±0.031 (a_w at 25°C) in T3 and T4 *Basundi* samples. The decrease in FFA values for each level of milk fat replacement with food gums showed significant ($p \leq 0.05$) decline. It reduced from 1.23 µeq/ml in control (T1) *Basundi* sample to 0.41 µeq/ml in T4 sample having lowest content of milk fat and highest content of food gums blend. The effect observed could be due to higher ratio of SNF/Fat in the low fat milks which have resulted in protective effect for fat. Similar results was reported for HMF content and Yield of *Basundi* by Patel and Upadhyay (2003 c, d) [23, 24]. With increase in Fat / SNF ratio yield decrease on the total solids basis and thus affected HMF content too.

Table 2: Influence of substitution of milk fat by food gums on physico-chemical properties and Yield of *Basundi*

Level of milk fat + food gum blend in milk (%, w/w)	Physico-chemical properties and Yield of *Basundi*						
	Acidity % LA	pH	FFA µeq/ml	HMF µmol/l	Water activity (aw) (25°C)	Viscosity m Pa.s (18°C)	Yield (kg /10 kg milk)
T1 (4.5 + 0.0)	0.39±0.09^a	6.56±0.13^a	1.23±0.09^a	12.26±0.46^a	0.98±0.030^a	51.62±0.62^a	4.25±0.17^a
T2 (3.0 + 0.2)	0.38±0.10^a	6.55±0.10^a	1.08±0.07^b	11.68±0.35^b	0.98±0.028^a	51.31±0.58^a	4.40±0.12^{ab}
T3 (1.5 + 0.3)	0.38±0.08^a	6.55±0.18^a	0.71±0.04^c	10.89±0.38^c	0.97±0.035^a	51.86±0.51^a	4.55±0.16^b
T4 (0.2 + 0.4)	0.37±0.11^b	6.57±0.19^a	0.41±0.03^d	09.76±0.31^d	0.97±0.031^a	52.25±0.48^a	4.50±0.13^b

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

Table 3: Influence of substitution of milk fat by whey protein concentrate (WPC-70) on average proximate composition of *Basundi*

Level of milk fat + WPC-70 in milk (%, w/w)	Compositional Attributes (%) of *Basundi*						
	Fat	Protein	Lactose	Ash	SNF	Sucrose	Total Solids
T1 (4.5 + 0.0)	10.60±0.51^a	09.20±0.35^a	10.30±0.03^a	1.64±0.02	21.15±0.76^a	14.10±0.30^a	45.85±1.12^a
T2 (3.0 + 1.5)	6.70±0.43^b	11.15±0.28^b	10.60±0.04^b	1.62±0.01	23.75±0.89^b	13.45±0.35^b	43.90±0.96^b
T3 (1.5 + 3.0)	3.20±0.29^c	12.75±0.32^c	10.85±0.05^c	1.61±0.02	25.94±0.92^c	12.90±0.28^c	42.00±1.05^c
T4 (0.2 + 4.5)	0.40±0.13^d	13.75±0.26^c	10.90±0.04^c	1.60±0.03	26.90±0.73^c	12.20±0.31^d	39.50±0.92^d

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

In the present study viscosity of the *Basundi* samples was controlled and concentration was discontinued upon reaching apparent viscosity similar to control (T1) sample, with a view to keep all the *Basundi* samples similar in physical appearance. Due to this a non-significant rise in viscosity of experimental samples was observed but yield increased significantly due to lower attainment of ratio of concentration with increase in food gums blend in *Basundi*. Marzieh and Mostafa (2008) reported use of blend of stabilizers in ice cream mix and its effect on viscosity. They reported increase

in viscosity at constant total solids level. In this study as viscosity was controlled and hence it resulted in reduction in total solids which led to increase in yield. The 5-Hydroxymethyl furfural (5-HMF) content of the *Basundi* samples also reduced significantly ($p \leq 0.05$) which decreased significantly ($p \leq 0.05$) from 12.26 µmol/l in control (T1) to 9.76 µmol/l being the lowest in sample T4. The observed effect could be due to lower concentration supported by significant reduction in total solids content (Table 1) in low fat *Basundi* samples and affecting values for Yield (Table 2) of low fat *Basundi* that increased from 4.25 kg/10 kg milk in T1 to 4.55 kg/10 kg milk being highest in T3 sample.

Effect of substitution of milk fat by food gums combination on sensory attributes of *Basundi*

The influence of incorporation of food gums for replacing milk fat on sensory qualities of the *Basundi* samples is presented in Figure 1. The colour and appearance score was significantly affected by reduction in fat content of the *Basundi*. It increased non-significantly from 12.16 in T1 sample which served as control with no added food gums to 12.29 in T2 sample of *Basundi*. Thereafter on higher replacement levels, the decrease was significant ($p \leq 0.05$) in T3 and was lower (11.00) in T4 sample. The observed effect could be due to lower time required in attainment of desired viscosity and concentration and thus minimal browning of the product.

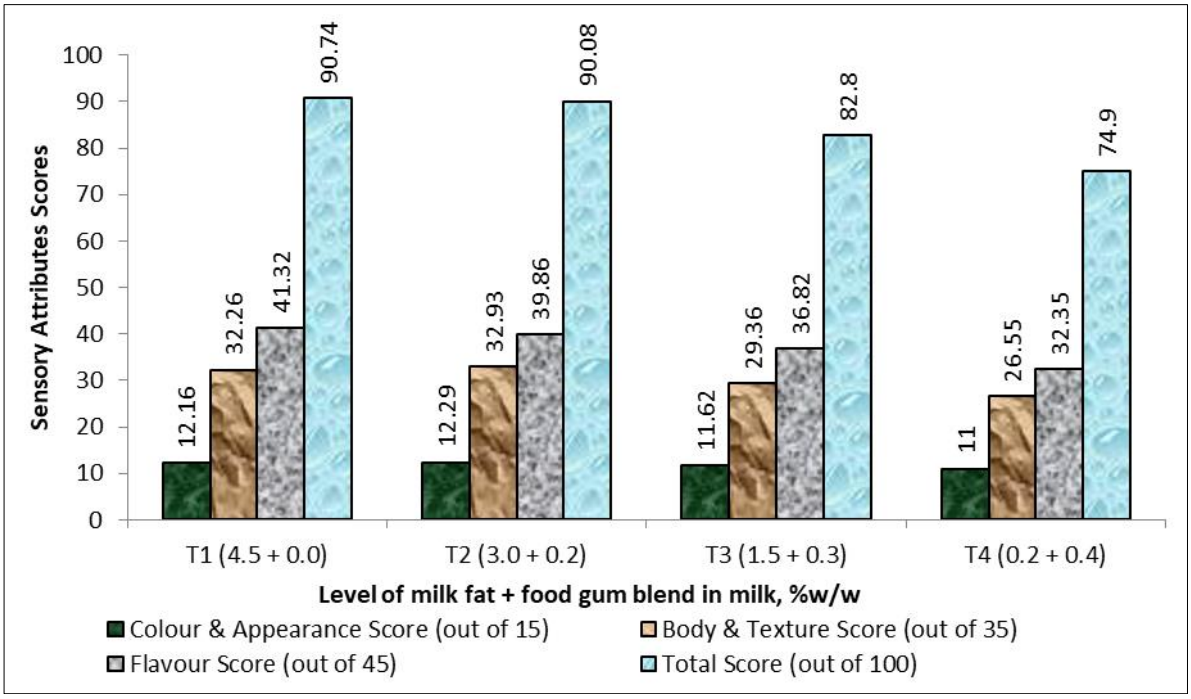

Fig 1: Influence of substitution of milk fat by food gums blend on sensory characteristics of *Basundi*

Similar trend was noted for body and texture score. Control sample (T1) had 32.26 body and texture score which was statistically at par with that of sample T2 (32.93). However, on further decrease in fat content and increase in food gums level, low fat *Basundi* samples T3 and T4 showed significant ($p \leq 0.05$) reduction up to 26.55 in T4 sample. Similar results was obtained by Puvanenthiran *et al.*, (2003) [26] for milk based gels upon addition of k-carageenan as food stabilizer.

Flavour score decreased non-significantly ($p \leq 0.05$) from 41.32 (Control sample, T1) to 39.86 in low fat *Basundi* samples (T2). The flavour score there after declined significantly ($p \leq 0.05$) in samples T3 and T4 and the later sample received significantly lower score of 32.35. Control sample (T1) received highest total score of 90.74±3.54 which remained at par with T2 sample (90.08±3.26), and T4 received significantly lower score (74.90±3.67) which remained statistically at par with T3.

Incorporation of food gums @ >0.2 per cent level resulted in lower sensory scores and was adjudged having slimy and sticky body and also lacking in typical cooked nutty flavor. It was also observed that at higher level (>0.3 per cent) of incorporation of food gums, emulsion in the experimental *Basundi* was destabilized during concentration process. To have similar viscosity in all experimental *Basundi* samples, concentration was discontinued at earlier stage which had resulted in decrease in total solids content and thus increased yield. Thus, food gums as fat replacer could be successfully employed @ 0.2 per cent with respective fat level in milk at 3.0 per cent.

To explore the possibilities of further reduction in fat content in milk for manufacture of low fat *Basundi*, it was decided to incorporate WPC-70, a functional and viscosity modifying ingredient. It was pre-decided to add WPC-70 at the same level of replacement of milk fat so as to keep similar total solids in milk.

Whey Protein Concentrates (WPC-70) as fat replacer

Whey proteins are excellent fat mimetic which can improve the body and texture of the low fat products. Whey proteins in particular have been used because they bind water and form weak networks that mimic the structure of full fat ice cream. WPC-70 was incorporated in the low fat Basundi and it was observed that viscosity was increasing with its level of incorporation which could be due to the binding of free water in Basundi. Márcia Cristina et al., (2012) [16] *reported use of whey protein concentrate in fat free dairy desserts.* They reported increase in viscosity and WPC had significant impact on sensory properties of fat free dairy dessert. *El-Zeini et al.*, (2016) also reported use of WPC for replacement of total solids at similar levels in ice cream mix, which is a product

similar in sucrose and total solids content. On the basis of preliminary studies, it was decided not to incorporate more total solids in the form of WPC-70 and hence incorporation of WPC–70 was restricted to the equivalent level of fat being replaced in the milk. WPC-70 was incorporated along with sugar, at partially concentration of milk (~1.9 - 2.0x). With the preliminary screenings, it was decided to restrict concentration level up to 2.1 to 2.2 times and it was adjudged by apparent viscosity/using refractometer and by taking the weight of the *Basundi* samples.

Effect of substitution of milk fat by WPC-70 on compositional attributes of *Basundi*

The incorporation of WPC-70 had tremendous influence on compositional attributes such as fat, protein, lactose, SNF, sucrose as well as total solids content of low fat *Basundi*. The mean values as depicted in Table 4 for fat content, reduced significantly ($p \leq 0.05$) at each level. *Basundi* sample T4 had the lowest fat (0.40%) and sample T1 (control) had the highest (10.60%) fat content. Protein content of the experimental *Basundi* samples showed significant increase ($p \leq 0.05$) at each level of incorporation of WPC. Control sample (T1) had lowest (9.20±0.35%) protein content and remained significantly lower as compared to rest of the experimental *Basundi* samples. Samples T2 and T3 were significantly different from each other and sample T3 had higher (12.75±0.32%) protein content. *Basundi* sample T4 had non-significantly higher protein content (13.75±0.26%) as compared to T3 and sample T4 remained highest among all *Basundi* samples under study. This observed effect was due to incorporation of WPC-70, a protein rich component, going in the blend of the low fat experimental *Basundi* samples. Pandiyan *et al.* (2012) and Vidisha and Arun (2013) [30] reported enrichment of protein in ice cream by employing whey protein concentrate in the ice-cream mix. They added whey protein concentrate on the basis of SNF to increase protein content.

Table 4: Influence of substitution of milk fat by whey protein concentrate (WPC-70) on physico-chemical properties and Yield of *Basundi*

Level of milk fat + WPC-70 in milk (%, w/w)	Physico-chemical properties and Yield of *Basundi*						
	Acidity % LA	pH	FFA µeq/ml	HMF µmol/l	Water activity (a_w) (25^OC)	Viscosity m Pa.s (18^OC)	Yield (kg /10 kg milk)
T1 (4.5 + 0.0)	0.39±0.06^a	6.56±0.06^a	1.23±0.04^a	12.86±0.31^a	0.98±0.021^a	52.36±1.71^a	4.25±0.15^a
T2 (3.0 + 1.5)	0.38±0.08^a	6.56±0.05^a	1.08±0.06^b	11.52±0.28^b	0.98±0.015^a	53.25±1.52^a	4.45±0.16^a
T3 (1.5 +3.0)	0.38±0.05^a	6.57±0.04^a	0.73±0.05^c	10.39±0.24^c	0.97±0.023^a	53.52±1.36^a	4.70±0.13^b
T4 (0.2 + 4.5)	0.37±0.07^a	6.58±0.06^a	0.42±0.03^d	9.63±0.16^d	0.97±0.025^a	53.79±1.52^a	4.95±0.17^c

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

Lactose content increased significantly ($p \leq 0.05$) from T1 sample to T2 and T3 samples of *Basundi* and thereafter it was at par in T4 samples. Control (T1) sample had the lowest lactose content (10.30±0.03%) and sample T4 had the highest lactose content (10.90±0.04%). The observed significant ($p \leq 0.05$) increase in lactose content could be because of the effect of WPC-70 which contains lactose. The ash content of the *Basundi* samples decreased non-significantly ($p \leq 0.05$). Control sample had highest ash content (1.64±0.02%), while sample T4 had the lowest (1.60±0.03%) ash content. Such observed effect could be due to the minerals supplied by the WPC-70. SNF content, as depicted in Table 4, had the similar significantly ($p \leq 0.05$) increasing trend as observed for protein content in low fat *Basundi* samples. A significant effect of increase in SNF content of low fat *Basundi* samples could be due to the incorporation of WPC-70, a SNF component (i.e. protein, lactose and minerals). Sucrose content of *Basundi* samples decreased significantly ($p \leq 0.05$) from 14.00±0.30% in T1 (control) sample to 12.20±0.31% in T4. This trend might be due to the fact that sugar was added at partially concentrated stage and its rate of addition was fixed @ 6% on the basis of quantity of milk taken for concentration. Thus varied ratio of concentration in experimental *Basundi* samples resulted in significant decrease in sucrose content of experimental *Basundi* samples. Incorporation of WPC-70, as fat replacer, in the experimental *Basundi* samples had significant ($p \leq 0.05$) decreasing effect on total solid content. It decreased at each level of incorporation of WPC-70. The observed effect could be due to lower concentration ratio attained with increasing level of WPC-70, and occurrence of such effect could be due to tendency of whey protein to bind free water, and thus leading to increase in viscosity.

Effect of substitution of milk fat by WPC-70 on physico-chemical attributes and Yield of *Basundi*

The effect of substitution of milk fat by incorporation of whey protein concentrate (WPC-70) on physico-chemical attributes of low fat *Basundi* is shown in Table 5. It could be seen from the tabulated values that replacement of milk fat by WPC-70 significantly ($p \leq 0.05$) decreased FFA (µ eq/ml) and HMF (µ mol/l) content and Yield (kg/10 kg milk) increased in experimental *Basundi*. The values of acidity (% LA), pH, water activity (a_w at 25°C) and viscosity (mPa.s at 18°C) of *Basundi* were also influenced but non-significantly ($p \leq 0.05$). Suneeta *et al.*, (2007) [27] and Khillari *et al.*, (2007) [13] reported significant ($p \leq 0.05$) increase in acidity by increasing level of WPC-70 in ice cream mix. However in present study, as viscosity was controlled, it resulted in increase in Yield (Table 4) and thus might have resulted in non-significant decrease in acidity. Vidisha and Arun (2013) [30] added WPC-70 to increase protein content by 40, 60 and 80% in ice-cream mix. They observed initial decrease and later at higher level of incorporation of whey protein concentrate, viscosity increased with increase in protein content, however in present study, viscosity was controlled, that resulted in significant decrease in total solids content in low fat *Basundi* samples (Table -3).

Lipolytic changes in most of the heat desiccated dairy products are related to thermo-stable lipases present in milk system. Their presence leads to breakdown of milk fat and generate free fatty acids (FFA), and depending upon their concentration it may result into off flavours in the product. In view of the importance of release of FFA in relation to the organoleptic quality of *Basundi*, the change in FFA content of low fat *Basundi* was accessed. The FFA content in the experimental *Basundi* samples decreased from 1.23±0.04

(Control) to 0.42±0.03 (µeq/ml) and the reduction in content observed was statistically significant ($p \leq 0.05$). Patel and Upadhyay (2003 d) [24] also reported increase in FFA content in relation to Fat/SNF ratio. The observed effect in the present study could be due to the reduction in fat content and simultaneous protective effect to fat provided by an increased SNF and protein content (Table 3). There are a number of different chemical compounds that are formed due to heating of milk in the presence of carbohydrate and proteins. Collectively it is known as Maillard reaction compounds, one of those is 5-Hydoxy Methyl Furfural (HMF) and its content is proportional to the time and temperature of processing. As *Basundi* is heat desiccated sweetened product, the Maillard reaction is bound to occur in *Basundi*, and once initiated, it reportedly continues during storage. To assess the extent of browning in *Basundi* samples, 5-HMF content of low fat *Basundi* was determined and significant decrease in HMF content from 12.86±0.31 to 9.63±0.16 in low fat sample was observed and such decrease was significant at each successive stage of reduction in fat content. The significant decrease could be due to the earlier ceasing of concentration process upon attainment of similar viscosity at lower total solids content and thereby decrease in processing time for the samples containing higher protein supplied in form of WPC-70 as fat mimetic. Such effect also impacted yield of reduced fat *Basundi*, which increased significantly at each level of reduction in fat content. Patel and Upadhyay (2003b,d) [22, 24] has reported rise in HMF content of *Basundi* at higher total solids level and thus decrease in total solids level in present study resulted in significant decrease in HMF content. Other physico-chemical properties like per cent lactic acid, pH, water activity and viscosity though varied but such variation was statistically non-significant.

Effect of substitution of milk fat by WPC-70 on sensory attributes of *Basundi*

The influence of incorporation of WPC-70 on sensory qualities of the reduced fat *Basundi* samples is shown in Figure 2. The colour and appearance score of low fat *Basundi* samples was significantly affected. Scores for this attribute initially decreased non-significantly from 12.56±0.28 (control sample) to 12.49±0.27 (T2) and then increased to highest score of 12.82±0.22 for T3 sample. Sample T4 received significantly lower score (11.73±0.19). Observed difference in the scores could be due to incorporation of WPC-70, which imparted whiter and glossy appearance, to a certain level which later resulted in slightly destabilized like appearance in sample T4. Asli and Meral (2009) [1] used whey protein concentrate in nonfat fermented milk drink. They reported addition of whey protein concentrate @ 2% positively influenced physical properties of the nonfat fermented milk drink. In the present study, body and texture scores obtained for reduced fat *Basundi* samples containing WPC-70 exhibited similar trend and colour and appearance score also followed the trend observed for body and texture score. Control sample had significantly ($p \leq 0.05$) higher (41.32±0.75) flavour score as compared to T3 and T4 samples, whereas it was non-significantly higher in T2 sample. Reduced fat *Basundi* sample T3 received highest total score (91.65±0.98) and was significantly higher than rest of the experimental *Basundi* samples.

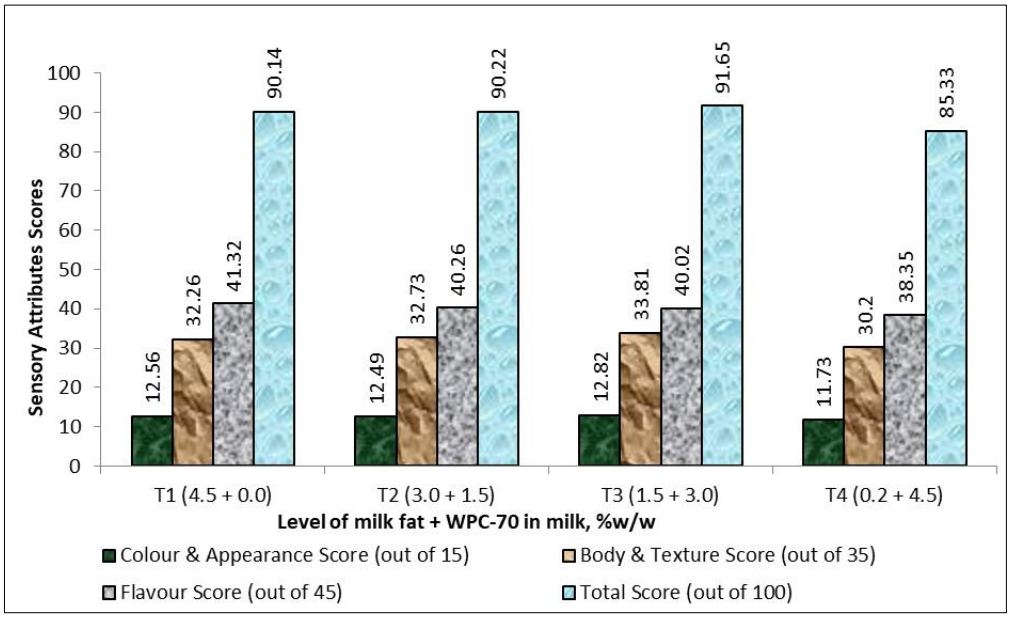

Fig 2: Influence of substitution of milk fat by whey protein concentrate (WPC-70) on sensory characteristics of *Basundi*

Conclusion

In the development of technology for manufacture of low fat *Basundi*, incorporation of food gums blend (sodium alginate and carrageenan base in 1:1 proportion) were tried at different levels (0.0, 0.2, 0.3 and 0.4% w/w) in accordance with reduction in fat content of milk form 4.5, 3.0, 1.5 and 0.2% respectively. Food gums blend @ 0.2% in milk having 3.0% fat resulted in sensorily acceptable quality of reduced fat *Basundi*. Further reduction in fat with increased amount of food gums blend resulted in lower flavor score, with very viscous, ropy body and chalky texture. To exploit further reduction in fat and there by calorie content, whey protein concentrate was evaluated. Instead of food gums blend WPC-70 was incorporated at equivalent level of substitution of fat, i.e. @ 0.0, 1.5, 3.0 and 4.5% w/w in milk. Incorporation of WPC-70 as fat replacer resulted in successful reduction of fat in milk upto 1.5%, without affecting sensory properties. These results suggested that the incorporation of WPC-70 in the manufacture of low fat *Basundi* as fat replacer has provided promising outcome in reducing fat content of *Basundi* up to 70 % level by addition of WPC-70 @ 3.0 % w/w in 1.5% fat milk.

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