

RESEARCH ARTICLE

Effect of incorporation of dietary fibers on reduced calorie *kulfi* containing whey protein concentrate

Apurba Giri¹ (✉) and H G Ramachandra Rao²

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Abstract: To improve the dietary value of *kulfi*, 50% of the sugar was replaced by stevia (at 0.05%), 3.0% whey protein concentrate (WPC) was added along with 0.5 and 1.0% dietary fiber pectin and wheat bran (WB). As the level of pectin and WB addition increased the specific gravity increased and freezing point decreased. At 1.0% pectin and WB addition the melting rate decreased and at 1.0% pectin and 0.5 and 1.0% WB addition there was a significant increase in hardness. Based on sensory analysis, *kulfi* with 0.5% added pectin was judged to be at par with the control.

Key words: *Kulfi*, Pectin, Wheat bran, Dietary fibers, Stevia, Whey protein concentrate

Introduction

Today, foods are not only intended to satisfy hunger and provide necessary nutrients for humans but also to prevent nutrition-related diseases and improve physical and mental well-being of the consumer. In this regard, functional foods play an outstanding role. Consumers more and more believe that foods contribute directly to their health. So, the current trend is functional foods development, to enhance the health attributes of widely consumed foods by fortifying with functional food ingredients. Functional foods are the foods which have some biological functionality besides the basic nutritional value or they may be regarded as conventional food products with health-

promoting ingredients or components that go beyond their traditional nutritive value. Those health-promoting ingredients are called as functional ingredients. Some examples of these active ingredients are dietary fiber, phytosterols, bio-active peptides, prebiotics, conjugated linoleic acid, omega-3-fatty acids, etc. (Giri and Kanawjia, 2013a, 2013b, 2014; Giri et al. 2014a).

Among different functional ingredients regular consumption of dietary fiber provides several health benefits. It possesses great potential for modulating the action of gut in both digestion and absorption of food. It improves gut motility, increases bowel passage and also plays a role in the reduction or prevention of diseases of the colon such as constipation, cancer and ulcers. Intake of dietary fiber reduces risk of coronary heart disease, stroke, hypertension and diabetes (Partula et al. 2020). Beside this, it reduces weight and improve immune function. The recommended daily dietary fiber intake is 28 g/day for adult women and 36 g/day for adult men (El-Salhy et al. 2017). Unfortunately, most persons consume less than half of the recommended levels of dietary fiber daily.

Pectin is a plant fiber obtained from the rind and peel of citrus fruits such as lemons, grapefruits, oranges and tangerines (Wang et al. 2015). Structurally, pectin is classified as a water soluble, complex polysaccharide, rich in the sugar – galactose and it is suggested to have health benefits to humans. It has the potential to lower serum cholesterol, particularly low-density lipoprotein (LDL) cholesterol, improve insulin resistance, and relief diarrhea. Pectin acts as de-toxicant, as regulator and protectant of the gastrointestinal tract, as immune system stimulant and as anti-ulcer and anti-nephrotic agent (Sande, 2018). Pectin, as the other dietary fiber components, helps to prevent a surge in blood glucose levels by promoting satiety, and possibly by reducing the rate of glucose uptake. Pectin is used in food as a gelling agent, particularly in jams and jellies. It reduces syneresis in jams and marmalades and increases the gel strength. It can also be used to stabilize acidic protein drinks, such as drinking yogurt, to improve the mouth-feel and the pulp stability in juice based drinks including as a fat substitute in baked goods. In general, levels of pectin used as a food additive are between 0.5 and 1.0%. It is also used as a source of dietary fiber.

¹Department of Nutrition; Mugberia Gangadhar Mahavidyalaya; Bhupatinagar-721425; Purba Medinipur; West Bengal; India

²Department of Dairy Technology; Dairy Science College; Karnataka Veterinary, Animal and Fishery Sciences University; Bangalore-560024; Karnataka; India; E-mail: hgrrao@gmail.com

Apurba Giri(✉)
E-mail: apurbandri@gmail.com

Wheat bran (WB) which is also considered as dietary fiber is the outer layer of wheat consists of thin-walled long rectangular cells. WB is packed with nutrition, and offers many dietary benefits. A cup (58 g) of WB contains 99% of the US recommended daily allowance (RDA) of fiber, 9.0g of protein, and 34% of the RDA for iron. WB is also high in magnesium, manganese, niacin, phosphorus, zinc and vitamin B₆. It helps to maintain normal bowel function and relieves occasional constipation, such as caused by changes in dietary habits or travel (McRorie, 2019). WB can be added to muffins, pancakes, biscuits, waffles, or even in cookies. A small amount of WB can be added to smoothies, especially when it is finely powdered.

Kulfi is a traditional Indian frozen dairy product which is liked by people of all ages from all over India. It has a composition almost similar to that of ice cream. *Kulfi* may be prepared from cow or buffalo milk or a combination thereof or from cream, and / or other milk products, with or without the addition of glucose, cane sugar, dextrose and, eggs, fruits, preserved fruits, fruit juices, nuts chocolate, edible flavors and permitted food colors. It may contain permitted stabilizers and emulsifiers, not exceeding 0.5% by weight. The mixture shall be suitably heated before freezing. The product shall contain not less than 10% milk fat, 3.5% protein and 36% total solids except that when any of the content of milk fat shall not be less than 8.0% by weight. Starch may be added to a maximum extent of 5.0% under a declaration on the label (Aneja et al. 2002). It differs from ice cream in that, it is not aerated. In traditional method, it is frozen in ice-salt mixture. In industrial production, standardized milk is concentrated to about half of the original volume and sugar is added. The mix is cooled and frozen at -20°C for 6 h. Typical *kulfi* formulation constitutes 9.0% milk fat, 17% milk solids-not-fat, 13% sugar and 1-2% nuts (optional).

Milk and dairy products are poor in food fibers and it is recommended to eat them along with fiber. The nutritive value of combined products is very high and they are tasty. To improve the dietary value of *kulfi* in our early studies in *kulfi* 0, 50, 60 and 70% sugar was replaced with 0, 0.05, 0.06 and 0.07% refined stevia extract powder (Rao and Giri, 2009), respectively. *Kulfi* prepared by replacing half the sugar content with stevia was adjudged at par with the control in sensory characteristics whereas more than 50% sugar replacement resulted in bitterness, lack of brownish appearance and presence of icy texture. In 50% sugar replaced with 0.05% stevia-added *kulfi*, whey protein concentrate (WPC) at 0, 2.0, 3.0 and 4.0% levels were separately incorporated. The 3.0% WPC-added *kulfi* was adjudged as best by a panel of judges. Above 3.0% WPC addition, the product was very soft and possessed undesirable whey flavor (Giri et al. 2013; Giri et al. 2014b).

To further enrich the stevia sweetened WPC incorporated *kulfi*, in the present study it was incorporated with different levels (0.5

and 1.0%) of dietary fibers (pectin and WB) separately and its effect on physical and sensory characteristics were studied.

Materials and Methods

Ingredients

Fresh cow milk was taken from Students' Experimental Dairy Plant, Dairy Science College, Bangalore, for preparation of *kulfi* in this investigation. Fresh cream (40% fat and 6.0% solids-not-fat) which was obtained after separating the fresh whole milk and 'Sagar' brand skim milk powder were used for standardization of milk (5.0% fat and 8.5 % solids-not-fat). Good quality cane sugar was purchased from the local market. Refined stevia extract powder (containing 91.1% stevioside) was obtained from Kubler Botanicals, Hubli. 'Aloch' brand Sodium alginate, used as stabilizer, was purchased from local market. WPC (70% protein), used in the present study, was obtained from Mahaan Group, New Delhi. Pectin as a dietary fiber used in the present study, was obtained from Ganesh Chemicals, Bangalore. 'Elite' brand WB was obtained from the local market and used for this experiment.

Production of dietary fiber added WPC incorporated stevia sweetened *kulfi*

Standardized milk (5.0% fat, 8.5% SNF) was condensed to half of its original volume in an open pan. Then at 65 °C, 0.3% sodium alginate, 6.5% Sugar, 0.05% stevia (Giri et al. 2014b), 3.0% WPC (Giri et al. 2013) and different levels of pectin (0.5 and 1.0%) and WB (0.5 and 1.0%) were added for different batches and mixed thoroughly (Table 1). The mix after cooling to room temperature was filled in moulds and hardened at -20 °C for 8 h. The products thus prepared were subjected to analysis for different physical and sensory attributes to maintain compare with control *kulfi* (6.5% sugar, 0.05% stevia, 3.0% WPC and no dietary fiber).

Analytical methods

Fat content in milk was determined by Gerber method and in cream and *kulfi* by Rose-Gottlieb method (IS: Part XI 1981). The milk solids-not-fat content in milk and protein content in *kulfi* were determined according to the method outlined in IS:10083 (1982) and AOAC (1980), respectively. Methods as described in IS: Part XI (1981) were followed to estimate contents of ash and moisture (gravimetric method) in *kulfi*. Carbohydrate content of *kulfi* was estimated by subtracting moisture, fat, protein and minerals from 100.

Specific gravity of *kulfi* mix was estimated at 30 °C by using a standard specific gravity bottle of 50 ml capacity, taking distilled water as the standard liquid. The melting rate of the *kulfi* was observed by drawing 50 g of the sample on a wire net placed on a funnel over a beaker immediately after removal from the hardening chamber. The time taken by the sample for complete

melt down and dripping into the beaker at room temperature (30°C) was noted. The melting rate was expressed as ml/15 min. Penetration value was determined using penetrometer (AIMIL, Associated Instrument Manufactures Pvt. Ltd., Bangalore) to assess hardness of *kulfi*. Penetration value was determined as soon as *kulfi* was drawn from the moulds after hardening. The distance in millimeters travelled by the cone in 5 s into the sample at room temperature was noted. For each sample, readings were recorded at 3 different spots and the mean value was noted. The freezing point of the *kulfi* mix was determined by using cryoscope (Cryostar I, Advanced Milk Instruments Manufacturer, USA).

Sensory analysis

Samples were judged by a panel of ten judges with a 9-point hedonic-scale score card (9 for liking extremely and 1 for disliking extremely). The judges were from the Faculty of Dairy Technology Department, Dairy Science College, Hebbal, Bangalore. The judges have not been trained for the product evaluation, but they are dairy professionals having sufficient knowledge about the sensory evaluation methods and the product characteristics. Scoring system for the characteristics was provided with standard descriptive phrases to help the judges to arrive at a decision. Judges were supplied with 4 to 5 coded samples of 30 g each as per IS: 6273 (1971). The analysis was performed in Sensory Laboratory. The panelists were allowed to use water and bland crackers for palate cleansing between the samples. The samples were evaluated always 2 h before or after the meals (Makhhal et al. 2011; 2014; 2013b).

Statistical analysis

All experiments were done in triplicate. The significant difference among the samples was determined by one way analysis of

variance (ANOVA) using IBM SPSS Statistics 20 software package. The data are presented as Means±Standard Error. When significant (5.0% level) differences were observed, individual means were compared using Tukey’s Post Hoc multiple comparison test (Sau et al. 2014).

Results and Discussion

Effect on composition

Due to addition of pectin or WB, net weight of *kulfi* increased, which decreased the concentrations of fat, protein, ash and moisture content in the product (Table 2) and increased the carbohydrate percentage.

Physical properties

Specific gravity

The specific gravity of control *kulfi* mix recorded was 1.095, as against 1.104 and 1.112, for 0.5 and 1.0% pectin addition, respectively (Fig. 1). The specific gravity of control sample was significantly ($p<0.05$) lower than both the pectin added *kulfi* mix samples. Between two pectin added *kulfi* mix, specific gravity significantly ($p<0.05$) higher at 1.0% of pectin addition, as against 0.5% level. Increased specific gravity may be due to high water solubility of pectin.

The specific gravity of 0.5 and 1.0% WB added *kulfi* mix recorded were 1.099 and 1.104, respectively. The specific gravity of control sample was significantly ($p<0.05$) lower than that of both WB added *kulfi* mix samples. There was significant ($p<0.05$) difference between 0.5 and 1.0% WB added *kulfi* mix on specific gravity.

Table 1: Levels of different ingredients added in 100 g concentrated milk for preparation of *kulfi*

Ingredients	Control	0.5% pectin added kulfi	0.5% WB added kulfi	1.0% pectin added kulfi	1.0% WB added kulfi
Sugar (%)	6.5	6.5	6.5	6.5	6.5
Stevia (%)	0.05	0.05	0.05	0.05	0.05
WPC (%)	3	3	3	3	3
Pectin (%)	0	0.5	0	1	0
WB (%)	0	0	0.5	0	1

Table 2: Effect of different levels of dietary fiber (pectin or WB) on composition of reduced calorie *kulfi* containing WPC

Levels of dietary fiber	Constituents (%)				
	Fat	Protein	Carbohydrate	Ash	Moisture
Control	10.4	8.7	16.8	1.0	63.0
0.5% pectin/ WB	10.3	8.6	17.2	0.99	62.7
1.0% pectin/ WB	10.3	8.6	17.6	0.99	62.4

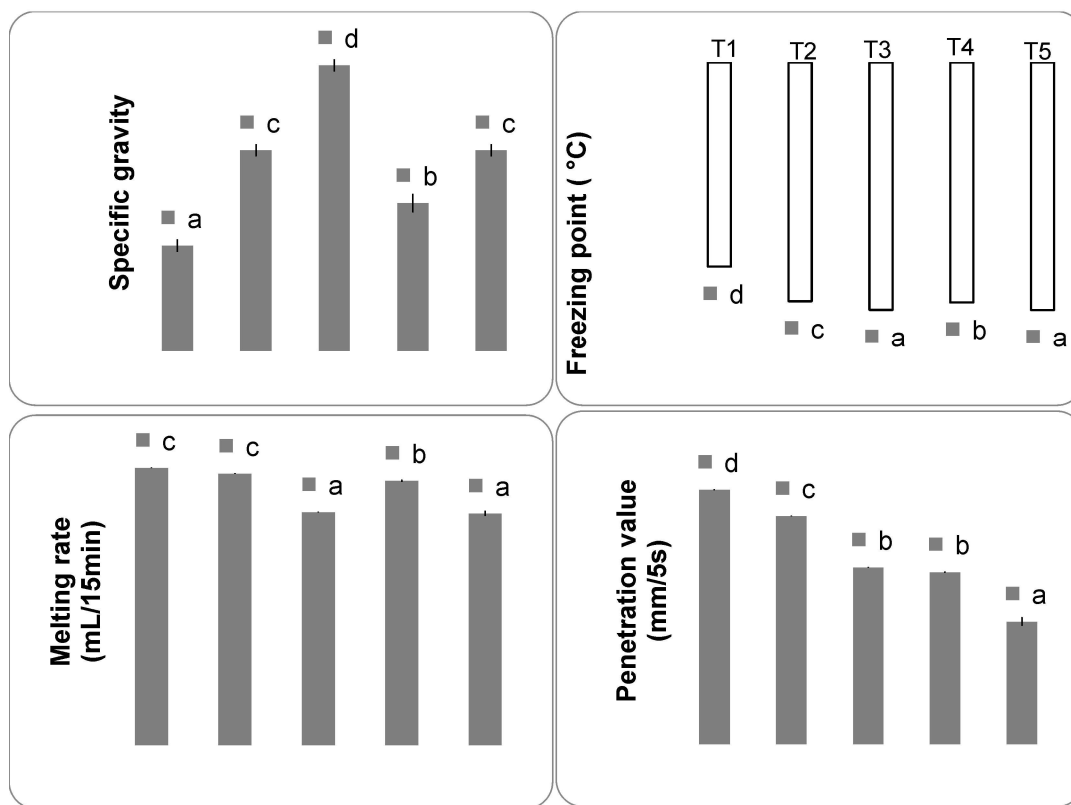


Fig. 1 Effect of different levels of fiber addition on specific gravity, freezing point, melting rate and penetration value of WPC incorporated sugar reduced, stevia sweetened *kulfi* mix/ *kulfi*; T1, T2, T3, T4, T5 imply control, 0.5% pectin, 1.0% pectin, 0.5% WB, 1.0% WB added *kulfi*, respectively; $n=3$; Different small alphabets indicate significantly different ($p<0.05$); Vertical bars indicate errors of means.

Addition of WB increased specific gravity due to higher water binding property of WB.

Freezing point

The freezing point of control *kulfi* mix recorded was -2.3620°C , as against -2.7628°C and -2.8628°C for 0.5 and 1.0% pectin addition, respectively. The freezing point of control sample was significantly ($p<0.05$) higher than both pectin added samples. Between two pectin added *kulfi* mix, freezing point was significantly ($p<0.05$) lower at 1.0% of pectin addition, as against 0.5% level. Pectin was soluble in *kulfi* mix. Due to increase of soluble particle in the solution freezing point decreased.

The freezing point of 0.5% and 1.0% WB added *kulfi* mix were -2.7768°C and -2.8648°C , respectively. The freezing point of control sample was significantly ($p<0.05$) higher than both WB added samples. There was significant ($p<0.05$) difference between 0.5 and 1.0% WB added *kulfi* mix on freezing point. When the WB was added since it binds water, the soluble constituents in the free water is concentrated, so freezing point decreased.

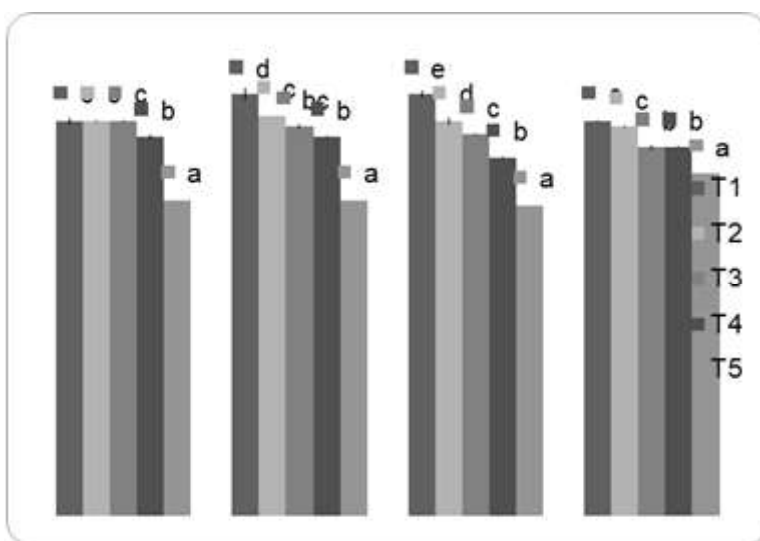
Melting rate

The melting rate (ml/15 min) of control *kulfi* recorded was 12.582, as against 12.322 and 10.582 for 0.5 and 1.0% pectin addition, respectively. There was no significant ($p<0.05$) difference in melting rate between control and 0.5% pectin added *kulfi*, but there was significant ($p<0.05$) difference of melting rate between control and 1.0% pectin added *kulfi*. Between two pectin added *kulfi*, melting rate significantly ($p<0.05$) lower at 1.0% of pectin addition as against 0.5% level.

The melting rate (ml/15 min) of 0.5% and 1.0% WB added *kulfi* were 12.00 and 10.52, respectively. There was significant ($p<0.05$) difference of melting rate between control and 0.5% WB added *kulfi* and control and 1.0% WB added *kulfi*. Melting rate of 0.5% WB added *kulfi* recorded significantly ($p<0.05$) higher than that of 1.0% addition.

Dietary fiber added *kulfi* samples with WB recorded lower melting rate compare to pectin addition. This could be attributed to the fact that WB with minute quantities of starch, possessed higher water binding property (Sui et al. 2018).

Fig. 2 Effect of different levels of fiber addition on sensory characteristics of WPC incorporated, sugar reduced, stevia sweetened *kulfi*; T1, T2, T3, T4, T5 imply control, 0.5% pectin, 1% pectin, 0.5% WB, 1.0% WB added *kulfi*, respectively; $n=3$; Different small alphabets indicate significantly different ($p<0.05$); Vertical bars indicate errors of means.



Pectin was highly soluble. However, it did not allow the mix viscosity to increase to the extent as that of WB added sample. Among the pectin added samples, as the level of fiber increased, the melting rate also decreased. This could be because of higher viscosity resulting from higher levels of pectin incorporation. The increased viscosity results in a tight, compact body which resisted melting.

At 0.5% level of fiber incorporation there was no significant ($p<0.05$) difference in melting rate of control and pectin added *kulfi* samples. This could be attributed to the limited water binding capacity of the pectin at lower level (0.5%). As the level of pectin incorporation increased (1.0%), greater quantities of water being bound by fiber resulted in significantly ($p<0.05$) lower melting rate of pectin added *kulfi* samples as compared to control *kulfi*.

Penetration value

The penetration value (mm/5 s) of control *kulfi* recorded was 30.96, as against 30.45 and 29.45 for 0.5 and 1.0% pectin addition, respectively. There was significant ($p<0.05$) difference in penetration value among control, 0.5% and 1.0% pectin added *kulfi*.

The penetration value of 0.5 and 1.0% WB added *kulfi* was 29.36 and 28.40 for 0.5 and 1.0% WB addition, respectively. The penetration value of all WB added samples were significantly ($p<0.05$) lower as compare to control. There was significant ($p<0.05$) difference between 0.5 and 1.0% WB added *kulfi* on penetration value.

Pectin and WB being water soluble, reduce the portion of free water, there by increased the viscosity of the product (Sui et al. 2018). This was responsible for lower penetration values of pectin and WB added samples, at all levels. As the level of dietary fiber in the *kulfi* increased, the penetration value of the sample decreased on account of greater amounts of water being bound

by the increased fiber content and as a result harder, compact body of *kulfi*.

Sensory characteristics

Color and Appearance

Control and all pectin added samples awarded same score 7.5 on color and appearance but for 0.5 and 1.0% WB added *kulfi* awarded 7.2 and 6, respectively (Fig. 2). The color and appearance score of control sample was significantly ($p<0.05$) higher than that of all WB added *kulfi* samples. There was significant ($p<0.05$) difference between 0.5 and 1.0% WB added *kulfi* on color and appearance score. Pectin had no negative effect on the color and appearance of the treated *kulfi*. So, pectin treated *kulfi* did not differ significantly ($p<0.05$) from the control *kulfi*. However, WB treated samples differ significantly ($p<0.05$) from the control. Judges opined that WB had dark specks of bran, which were visible on the product body.

Body and Texture

The body and texture score of control *kulfi* awarded was 8, as against 7.6 and 7.4 for 0.5 and 1.0% pectin added *kulfi*, respectively. There was significant ($p<0.05$) difference on body and texture score of pectin added samples with control sample. However, there was no significant ($p<0.05$) difference between 0.5 and 1.0% pectin added *kulfi*.

For 0.5% and 1.0% WB added *kulfi* 7.2 and 6 were awarded, respectively on body and texture score. There was significant ($p<0.05$) difference in all WB added *kulfi* when compared with control *kulfi* as well as between 0.5 and 1.0% WB added *kulfi* on body and texture score.

Flavor

The flavor score of control *kulfi* was awarded 8, as against 7.5 and 7.2 for 0.5 and 1.0% pectin added *kulfi* respectively. The

flavor score of control *kulfi* was significantly ($p < 0.05$) higher than that of all pectin added *kulfi*. Probably higher level of pectin addition may have negative influence on the flavor.

For 0.5 and 1.0% WB added *kulfi* 6.8 and 5.9 were awarded, respectively on flavor score. The flavor score of control *kulfi* was significantly ($p < 0.05$) higher than that of all wheat bran added *kulfi*. There was significant ($p < 0.05$) difference of flavor score between 0.5 and 1.0% WB added *kulfi* with control *kulfi*. When levels of wheat bran addition increased the flavor score decreased significantly ($p < 0.05$) due to its powdery flavor.

Overall acceptability

The overall acceptability score of control *kulfi* awarded was 7.5, as against 7.4 and 7.0 for 0.5 and 1.0% pectin added *kulfi*, respectively. There were no significant ($p < 0.05$) difference between control and 0.5% pectin added *kulfi* on overall acceptability score, but there was significant ($p < 0.05$) difference between control and 1% pectin added *kulfi* on overall acceptability score. Between 0.5 and 1.0% pectin added *kulfi* there was significant ($p < 0.05$) difference on overall acceptability score. Probably higher level of pectin addition may have negative influence on the flavor.

For 0.5 and 1.0% WB added *kulfi* 7 and 6.5 were awarded, respectively on overall acceptability score. There was significant ($p < 0.05$) difference between 0.5 and 1.0% WB added *kulfi* with control *kulfi* on overall acceptability score. Between 0.5 and 1.0% WB added *kulfi* there were significant ($p < 0.05$) difference on overall acceptability scores. As the levels of addition of WB increased the score of overall acceptability decreased significantly ($p < 0.05$) because WB treated *kulfi* possessed chalky flavor and chewy body at higher level. The judges adjudged the 0.5% pectin added *kulfi* on par with the control *kulfi*

Conclusion

Due to water soluble characteristics of pectin and water binding property of wheat bran the physical properties of *kulfi* or *kulfi* mix changed significantly ($p < 0.05$) at the higher level of pectin and WB addition. At the higher levels of WB addition lower sensory scores were obtained due to visible dark specks of WB, and a chalky or powdery flavor and chewy body. Even at the higher levels of pectin lower flavor scores were evident. So, it is concluded that a fiber fortified, WPC incorporated, stevia sweetened *kulfi* with good sensory properties could be made by incorporating 0.5% pectin.

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