Research Article

Chemical Analysis of Low Calorie Fiber enriched Herbal *Gulabjamun*

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Abstract

Research was conducted to examine the effect of *Tulsi* as an herb, Oat as fibre content and Sorbitol as fat replacer on the chemical properties of low calorie fiber enriched herbal *Gulabjamun*. The objective of the present research was to develop improved herbal based *Gulabjamun* with health benefits beyond those of traditionally formulated *Gulabjamun*. The product was manufactured by different ratio of Sorbitol (2%, 4% and 6%), Oat flour (10%, 15% and 20%) and *Tulsi* extract (10%, 15% and 20%). The mean score of chemical properties evaluated of the optimized product were found significantly ($P<0.01$) different with the control one. The moisture obtained in the optimized product was 30.19%, Fat content 11.41%, Protein 9.07%, Ash 1.87%, Total Sugar 54.39% and Fiber content calculated was 3.85%. The DPPH activity, ABTS activity and total phenol content the optimized product obtained was 58.07, 2.94 and 354.33 respectively.

Keywords: Gulabjamun, Tulsi, Sorbitol, Oat flour, Herbal

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Introduction

Traditional dairy products have great commercial significance as they account for over 90 per cent of all dairy products consume in the country [1]. About 52 to 55 per cent milk produce is converted into variety of Indian milk product by traditional sector (*Halwai* or sweet meat makers) using process such as heat desiccation, heat acid coagulation and fermentation, out of which about 5.5 percent of total milk production is utilize for *Khoa* making in India.

Traditional dairy products and sweets are an integral part of Indian heritage. These products have great social, religious, cultural, medicinal and economical importance and have been developed over a long period with the culinary skills of homemakers and *Halwais*. In addition to preserve of milk solids for longer time at a room temperature, manufacture of traditional dairy products add value to milk and also provide considerable employment opportunity. It is estimated that about 50% of total milk produced in India is converted into traditional milk products. Traditional dairy products not only have established market in India but also great export potential because of strong presence of Indian Diaspora in many parts of the world [2]. Milk has been an essential part of Indian diet from times immemorial. Milk and milk products play a very important role in human health and Dairy industry.

Gulabjamun is a popular Khoa based sweet. Originally it was made with *Khoa* and *Maida*. As it looks like monsoon fruit ―*Jamun* and is flavored with ―rose water. It got the name of *Gulabjamun*.

Gulabjamun in India is characterized by an unorganized nature of business. There is no denying the fact that indigenous products have come to stay as a vital fiber in the fabric of the country‘s dairy industry. Obviously, the indigenous products have a big potential of becoming the main stay of the emerging dairy industry under the organized sector and technological developments in their production will have far-reaching implication on it.

Gulabjamun refers to the indigenous dairy product. Almost all the states of the country use *Gulabjamun* as one of the essential and most commonly consumed sweet. Different states using different shapes and size of *Gulabjamun* viz; cylindrical, oval and spherical, but most commonly found shape is spherical.

The gross chemical composition of *Gulabjamun* varies widely depending on numerous factors, such as composition and quality of *Khoa*, proportion of ingredients, sugar syrup concentration, etc. The composition of *Gulabjamun*, on the drained weight basis, varies in the following range: moisture 25 – 35 percent, fat 8.5 – 10.5 percent, protein 6 – 7.6 per cent, ash 0.9 – 1.0 per cent and total carbohydrates 43 – 48 per cent.

In *Gulabjamun* manufacture, dipping in sugar syrup is a key unit operation. This gives not only its characteristic sweetness but also its typical texture. The characteristic sweetness is only due to the diffusion of sugar syrup into fried *Gulabjamun* balls. Hence the diffusion is one of the key processes taking place in *Gulabjamun* manufacture.

Sorbitol

It has been used in processed foods for half of century as sweetener, humectants and texturizing agent. It is a natural sugar alcohol present in many fruits is especially in cherry and pear. Industrially, it is obtained by hydrogenation of glucose derived from starch and invert sugar [3]. Sorbitol has got a smooth mouth feel, and is 0.6 times as sweet as sucrose. It is very stable and chemically uncreative, and can withstand high temperatures and does not participate in Maillard reaction. It combines well with other food ingredients, including sugar, protein, vegetables, fats and functions well in chewing gums, frozen desserts, icings and fillings.

Tulsi

Tulsi belongs to family *Lamiaceae* is widely distributed in tropical and warm temperate regions. The plant is commonly used in folk medicines to treat different diseases for e.g. upper respiratory tract infections, diarrhea, headache, ophthalmic, skin diseases, pneumonia and also a treatment for cough, fever and conjunctivitis. There are about 160 species in this genus broadly dispersed over the warm regions of the globe.

Medicinal properties

- Oil is reported to possess antibacterial properties.
- It inhibits the in vitro growth of Mycobacterium tuberculosis and *Micrococcus pyogenes.*
- It has antitubercular activity as one-tenth potency of streptomycin.
- Oil from green type is active against *Salmonella typhii*.
- Green type *Tulsi* extract of leaves are active against Escherichia coli.
- It is helpful in treatment of cold cough, kidney stone, heart disorder, mouth and skin infection.

Oat

Oats (*Avena sativa*) is a cereal grain, having numerous uses in foods; most commonly, they are rolled or crushed into oatmeal, or ground into fine oat flour. Oatmeal is chiefly eaten as porridge, but may also be used in a variety of baked goods, such as oatcakes, oatmeal cookies and oat bread. Oats are also occasionally used in several different drinks. In Britain, they are sometimes used for brewing beer. Oat extract can also be used to soothe skin conditions.

Oats are generally, considered 'healthful', or a health food, being touted commercially as nutritious. The discovery of their cholesterol-lowering properties[1] has led to wider appreciation of oats as human food.

Materials and Methods

The experiment "Process Optimization for manufacture of low calorie and fiber enriched Herbal *Gulabjamun*" was conducted in the Laboratory of Animal Husbandry & Dairying and Centre of Food Science & Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experimental techniques were employed as under.

Manufacturing Method

The low calorie and fiber enriched Herbal *Gulabjamun* has been manufactured by using following flow chart as shown in **Figure** 1.

The fat content of *Gulabjamun* was estimated by using Soxhlet apparatus (Socs-plus). Soxhlet method is one of the standard methods for analysis of fat in food. The method is recognized by the [4]. The protein content of *Gulabjamun* was estimated by using Kjeldahl method described by Davis and [5].Moisture content was calculated as per the method of [4]. Approximately, 3 g sample of *Gulabjamun* was accurately weighed into a silica crucible and kept for charring on hot plate for 2 h. After that the *Gulabjamun* sample was kept for ashing in a muffle furnace at 550 ± 2 °C for 4 h. [4]. Total Antioxidant Status (TAS) was measured spectrophotometrically [6]. Total oxidant status (TOS) was measured using Erel's TOS method, [7]. Dietary fiber content in Gulabjamun was measured by the enzymatic and gravimetric method based on [8].

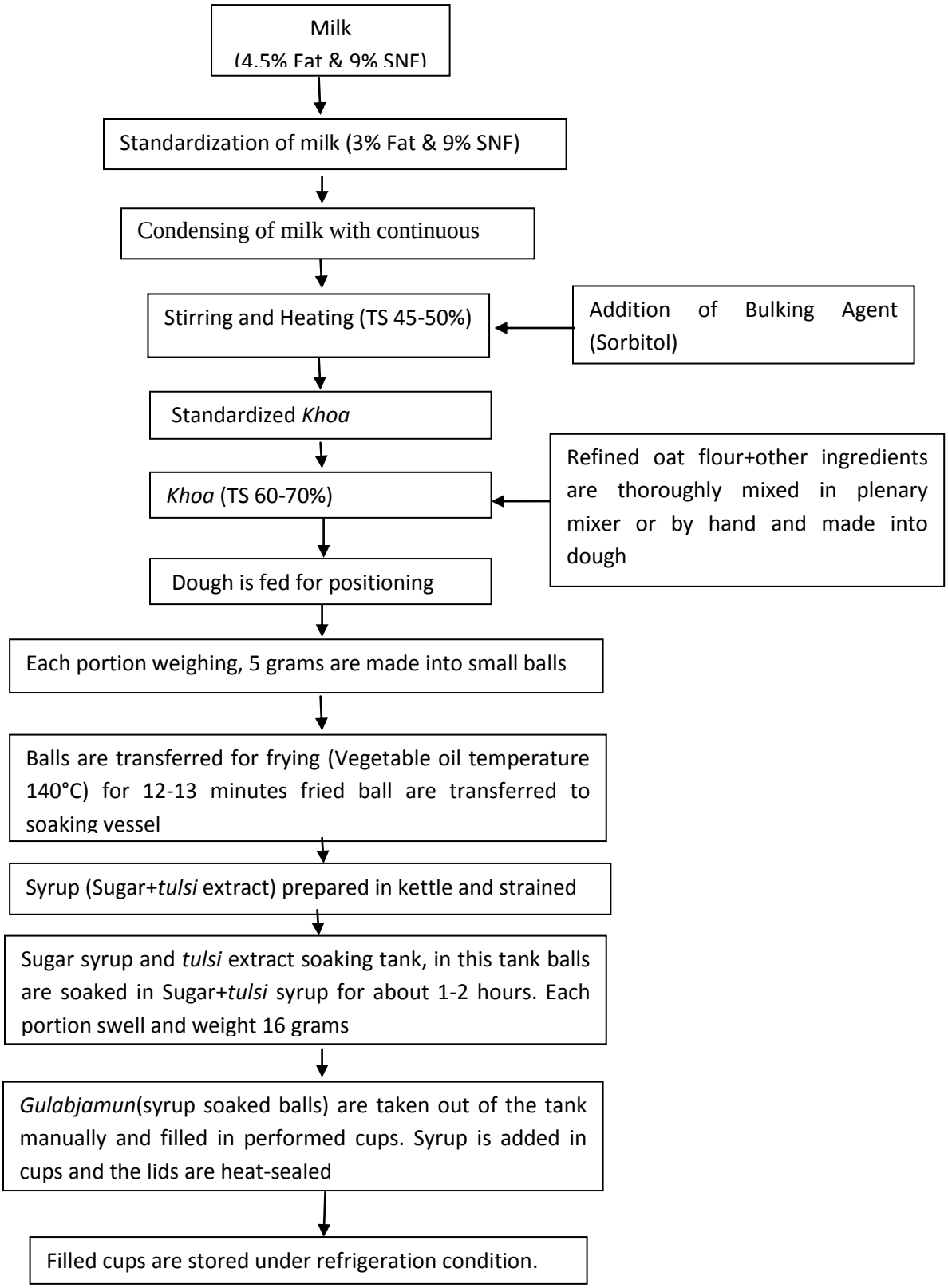

Figure 1 Flow diagram for manufacturing of low calorie and fiber enriched Herbal *Gulabjamun*

Results and Discussions

Moisture

Effect of different Sorbitol levels on Moisture of low calorie fiber enriched herbal Gulabjamun

The mean value of moisture (30.197) of low calorie fiber enriched herbal *Gulabjamun* was significant when it was

manufactured with 6% Sorbitol. The maximum mean value of moisture (30.380) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 6% Sorbitol and it was also found significant. While the minimum mean value of moisture (27.277) was obtained when it was prepared with 2% Sorbitol and it was found non-significant (**Table 1**). The result is in agreement with [9]. The moisture contents and the values of moisture in non-fat substance of the cheeses made with fat replacers were significantly higher than low fat control cheese [10].

Table 1 Mean Score of Moisture w.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	30.183	30.363	30.380
A1B2	29.243	29.577	29.797
A1B3	29.330	29.560	29.560
A2B1	28.517	28.720	28.870
A2B2	28.540	28.660	28.867
A2B3	27.277	27.470	27.663
A3B1	27.427	27.640	27.910
A3B2	28.010	28.140	28.553
A3B3	29.050	29.513	30.197

Effect of different Oat flour levels on Moisture of low calorie fiber enriched herbal Gulabjamun

The mean value of moisture (30.197) of low calorie fiber enriched herbal *Gulabjamun* was significant when low calorie fibre enriched herbal *Gulabjamun* was manufactured with 20% Oat flour. The maximum mean value of moisture (30.380) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 10% Oat flour and it was non-significant. While the minimum mean value of moisture (27.277) was obtained when it was prepared with 20% Oat flour and it was also found non-significant (Table 1). Moisture content of *Gulabjamun* was significantly lower when blended with Wheat bran. Among the different treatments values increased significantly as the level of wheat bran increased from 5to 10 percent. Higher moisture content in *Gulabjamun* blended with Wheat bran could be due to soaking of water by the wheat bran during *Khoa* preparation [11].

Effect of different Tulsi extract levels on Moisture of low calorie fiber enriched herbal Gulabjamun

The mean value of moisture (30.197) of low calorie fiber enriched herbal *Gulabjamun* was significant. In this case the *Gulabjamun* has been manufactured from 20% *Tulsi* extract. The maximum mean value of moisture (30.380) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% *Tulsi* extract. While the minimum mean value of moisture (27.277) was obtained when it was prepared with 10% *Tulsi* extract and it was found non-significant (Table 18).

Interactional effect of Sorbitol, Oat flour and Tulsi extract on Moisture of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the moisture of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of moisture (30.197) has been obtained with $A_3 \times B_3 \times C_3$combination which was statistically at par with A×B×C significance level is 0.0084 which is less than 0.01 and therefore shows 0.01 level of significance (**Table 2**).The minimum mean value of moisture (27.277) obtained with different combination of Sorbitol, Oat flour and *Tulsi* extract were found non-significant. The mean moisture values have been shown graphically in **Figure 2**.

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.0875.The standard error difference of two means were 0.1238. The critical difference (CD) of the combinations of these three different combinations obtained was 0.1125 (**Table 3**).All the three values shows that these are significant.

Fat

Effect of different Sorbitol levels on Fat of low calorie fiber enriched herbal Gulabjamun

The mean value of fat (11.417) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of fat (14.727) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 2% Sorbitol and this value was non-significant. While the minimum mean value of fat (11.417) was obtained when it was

prepare with 6% Sorbitol and it was found significant (**Table 4**). A highly negative correlation was observed between fat and protein content and between moisture and sorbitol content. Ash content exhibited a positive and highly significant correlation with fat and sorbitol content [12].

Table 2 ANOVA table for Moisture w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	15.651	15.651	680.486	0.0000
Factor A	2	36.391	18.195	790.981	0.0000
Factor B	2	0.055	0.027	1.189	0.3125
Factor A × B	4	30.070	7.518	326.802	0.0000
Factor C	2	3.273	1.637	71.151	0.0000
Factor A × C	4	0.445	0.111	4.840	0.0021
Factor B × C	4	0.266	0.066	2.887	0.0307
Factor A×B×C	8	0.273	0.034	1.486	0.0084
Error	54	1.242	0.023		
Total	80	72.016			

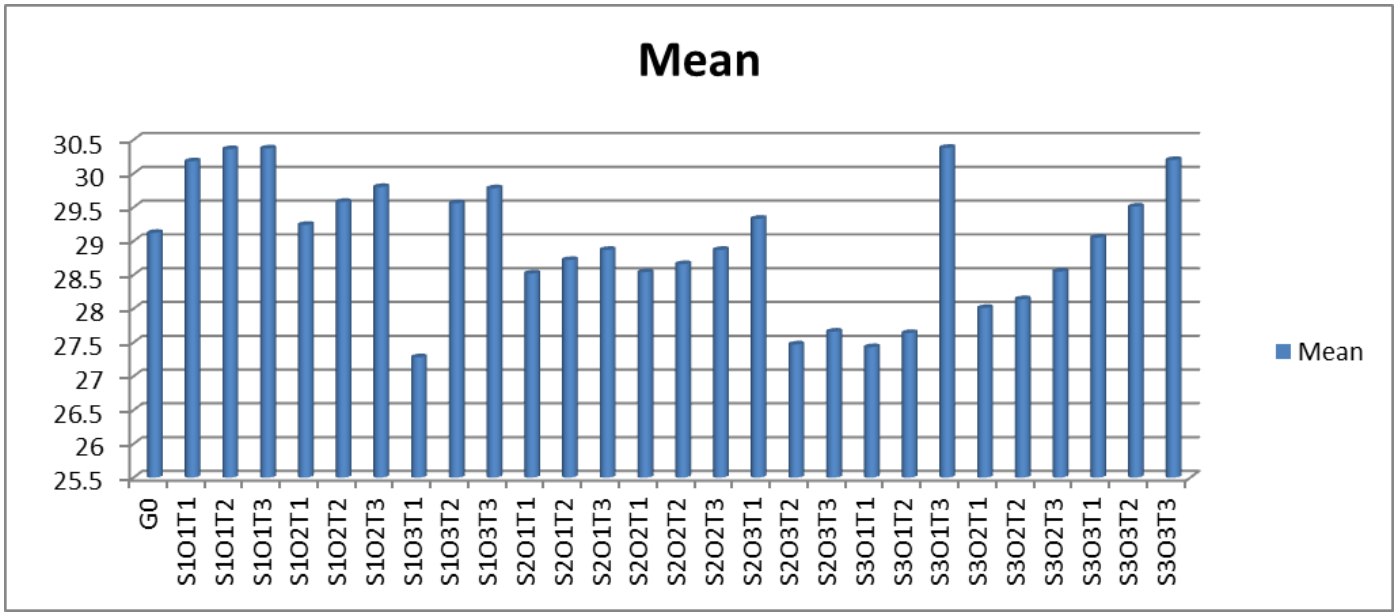

Figure 2 Mean Score Graph of Moisture w.r. to different treatments

Table 3 SE (m), SE (d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0292	0.0292	0.0292	0.0505	0.0505	0.0505	0.0875	0.0619
SE (d)	0.0413	0.0413	0.0413	0.0715	0.0715	0.0715	0.1238	0.0277
CD	0.0831	N.S.	0.0831	0.1439	0.1439	0.1439	0.1125	0.0557

Table 4 Mean Score of Fat w.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	14.727	14.527	14.357
A1B2	14.217	14.117	13.960
A1B3	13.823	13.700	13.503
A2B1	13.297	13.137	12.953
A2B2	12.660	12.393	12.257
A2B3	12.113	12.297	12.517
A3B1	11.963	11.977	11.830
A3B2	11.750	11.663	11.793
A3B3	11.697	11.520	11.417

Effect of different Oat flour levels on Fat of low calorie fiber enriched herbal Gulabjamun

The mean value of fat (11.417) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of fat (14.727) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 10% Oat flour. This value was non-significant. While the minimum mean value of fat (11.417) was obtained when it was prepare with 20% Oat flour and it was found significant (Table 4). Significant decrease in fat content of *Gulabjamun blended* with wheat bran as compared to control *Gulabjamun* was recorded this might due to replacement of *Khoa* by low fat content wheat bran as well as more moistures absorption capacity of wheat bran, that absorb more sugar syrup and increase moisture content of final product and combine result in decreases of fat content of final product. The results are in agreement with previous research worker [13].

Effect of different Tulsi extract levels on Fat of low calorie fiber enriched herbal Gulabjamun

The mean value of fat (11.417) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of fat (14.727) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 10% *Tulsi* extract and found non-significant. While the minimum mean value of fat (11.417) was obtained when it was prepare with 20% *Tulsi* extract and was found significant (Table 4).

Interactional effect of Sorbitol, Oat flour and Tulsi extract on Fat of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the fat content of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of fat (11.417) has been obtained with $A_3 \times B_3 \times C_3$which was statistically at par with A×B×C significance level is 0.0000 which shows less value than 0.01 and thus can be said that it has 0.01 level of significance (**Table 5**).The minimum mean value of fat (11.417) obtained with different combination of Sorbitol, Oat flour and *Tulsi* extract were found significant. The graphical representation of mean value of fat has been shown in **Figure 3**.

Table 5 ANOVA table for Fat w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	36.313	36.313	9078.258	0.0000
Factor A	2	77.314	38.657	8981.471	0.0000
Factor B	2	6.532	3.266	758.836	0.0000
Factor A × B	4	0.955	0.239	55.475	0.0000
Factor C	2	0.460	0.230	53.433	0.0000
Factor A × C	4	0.124	0.031	7.204	0.0001
Factor B × C	4	0.126	0.031	7.317	0.0001
Factor A×B×C	8	0.610	0.076	17.726	0.0000
Error	54	0.232	0.004		
Total	80	86.354			

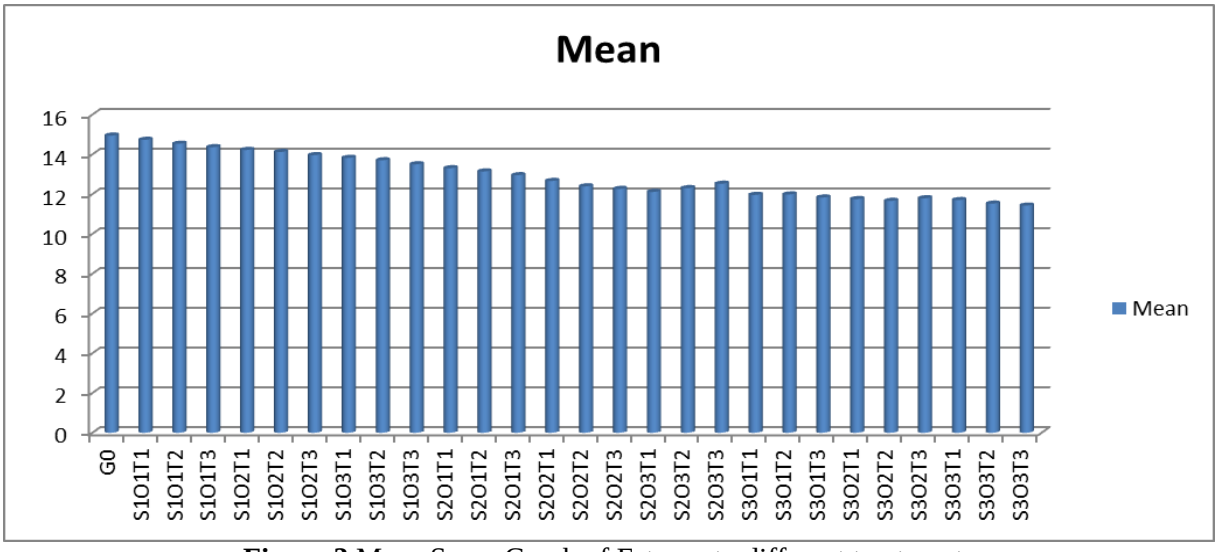

Figure 3 Mean Score Graph of Fat w.r. to different treatments

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.0365.The standard error difference of two means were 0.0516. The critical difference (CD) of the combinations of these three different combinations obtained was 0.1039 (**Table 6**). These three different values are in significance relation with each other.

Table 6 SE (m), SE (d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0122	0.0122	0.0122	0.0211	0.0211	0.0211	0.0365	0.0081
SE (d)	0.0172	0.0172	0.0172	0.0298	0.0298	0.0298	0.0516	0.0115
CD	0.0346	0.0346	0.0346	0.0422	0.0422	0.0422	0.1039	0.0232

Protein

Effect of different Sorbitol levels on Protein of low calorie fiber enriched herbal Gulabjamun

The mean value of protein (9.077) of low calorie fiber enriched herbal *Gulabjamun* was significant when it was manufactured with 6% Sorbitol. The maximum mean value of protein (9.643) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 2% Sorbitol and was found non-significant. While the minimum mean value of protein (8.217) was obtained when it was prepare with 6% Sorbitol and it was also found non-significant (**Table 7**). A highly negative correlation was observed between fat and protein content and between moisture and sorbitol content. Ash content exhibited a positive and highly significant correlation with fat and sorbitol content [12].

Table 7 Mean Score of Protein w.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	8.810	8.883	9.063
A1B2	9.190	9.280	9.353
A1B3	9.440	9.543	9.643
A2B1	8.373	8.410	8.377
A2B2	8.470	8.480	8.510
A2B3	8.547	8.583	8.617
A3B1	8.377	8.400	8.217
A3B2	8.443	8.537	8.833
A3B3	9.003	9.063	9.077

Effect of different Oat flour levels on Protein of low calorie fiber enriched herbal Gulabjamun

The mean value of protein (9.077) of low calorie fiber enriched herbal *Gulabjamun* was significant when it was prepared with 20% Oat flour. This value has significant interactions with other variables. The maximum mean value of protein content (9.643) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was again prepared with 20% Oat flour but have non-significant interactions with other variables. While the minimum mean value of protein (8.217) was obtained when it was prepare with 10% Oat flour and it was found non-significant (Table 7). Significant decrease in protein content of *Gulabjamun* blended with wheat bran as compared to control *Gulabjamun* was due to protein content in cow milk *Khoa* is 19.1 per cent which is replaced by wheat bran which contain protein 9 per cent and increase in moisture content of final product. BIS recommended minimum protein content of packaged *Gulabjamun* as 8.00 per cent. [14] reported that protein content of rasogolla was varied according to starches used as binding material.

Effect of different Tulsi extract levels on Protein of low calorie fiber enriched herbal Gulabjamun

The mean value of protein (9.077) of low calorie fiber enriched herbal *Gulabjamun* was significant using 20% *Tulsi* extract. The maximum mean value of protein (9.643) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% *Tulsi* extract but have non-significant interactions with other variables. While the minimum mean value of protein (8.217) was obtained when it was prepare with 20% *Tulsi* extract and it was found non-significant when it was compared with other variable combinations (Table 7).

Interactional effect of Sorbitol, Oat flour and Tulsi extract on Protein of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the protein of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of protein (9.077) has been obtained with $A_3 \times B_3 \times C_3$combination which was statistically at par with A×B×C significance level is 0.0001 which shows 0.01 level of significance (**Table 8**). Since the value is less than 0.01.The minimum mean value of protein (8.217) obtained with different combination of Sorbitol, Oat flour and, *Tulsi* extract were found non-significant. The historical graph in **Figure 4** shows the mean protein values.

Table 8 ANOVA table for Protein w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	4.051	4.051	810.248	0.0000
Factor A	2	8.546	4.273	781.126	0.0000
Factor B	2	3.540	1.770	323.509	0.0000
Factor A × B	4	0.748	0.187	34.185	0.0000
Factor C	2	0.179	0.090	16.379	0.0000
Factor A × C	4	0.068	0.017	3.124	0.0220
Factor B × C	4	0.074	0.019	3.392	0.0151
Factor A×B×C	8	0.213	0.027	4.876	0.0001
Error	54	0.295	0.005		
Total	80	13.665			

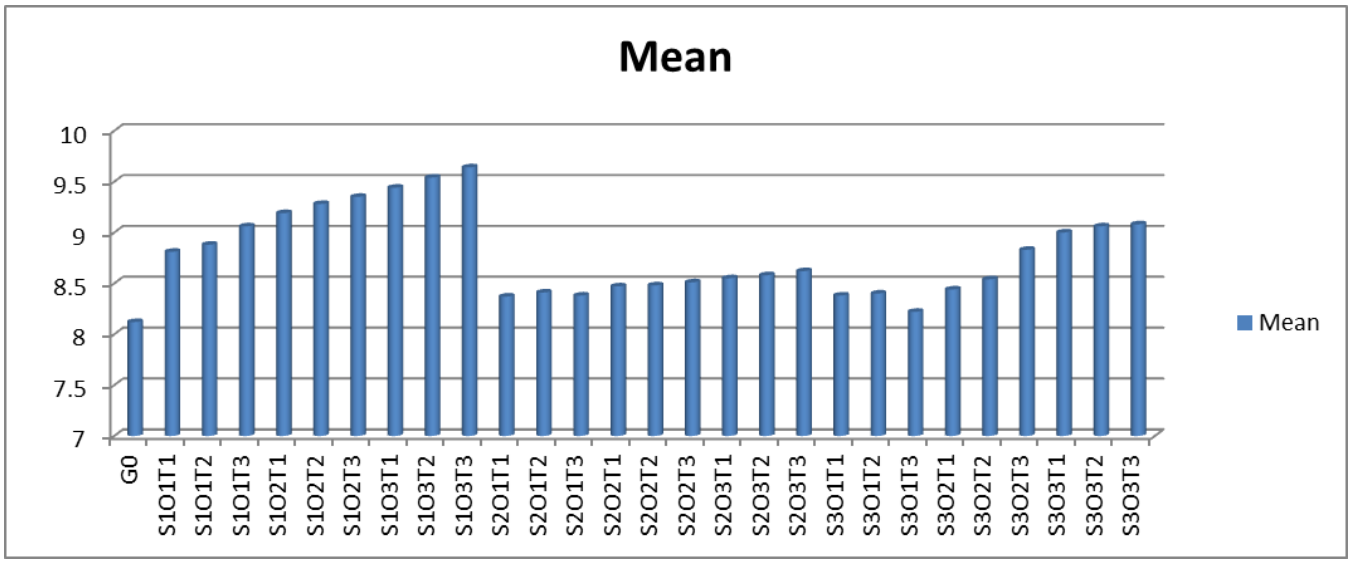

Figure 4 Mean Score Graph of Proteinw.r. to different treatments

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.0408.The standard error difference of two means were 0.0577. The critical difference (CD) of the combinations of these three different combinations obtained was 0.1162 (**Table 9**).These data were significant when compared with separate combinations of Sorbitol, Oat flour and *Tulsi* extract.

Table 9 SE (m), SE (d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0136	0.0136	0.0136	0.0236	0.0236	0.0236	0.0408	0.0091
SE (d)	0.0192	0.0192	0.0192	0.0333	0.0333	0.0333	0.0577	0.0129
CD	0.0387	0.0387	0.0387	0.0671	0.0671	0.0671	0.1162	0.0260

Ash

Effect of different Sorbitol levels on Ash of low calorie fiber enriched herbal Gulabjamun

The mean value of ash (1.873) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of ash (1.873) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 6% Sorbitol. While the minimum mean value of ash (1.197) was obtained when it was prepared with 4% Sorbitol and it was found non-significant (**Table 10**).

Table 10 Mean Score of Ash w.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	1.233	1.373	1.570
A1B2	1.663	1.687	1.710
A1B3	1.817	1.850	1.863
A2B1	1.197	1.430	1.437
A2B2	1.513	1.520	1.617
A2B3	1.680	1.763	1.863
A3B1	1.477	1.560	1.667
A3B2	1.690	1.747	1.780
A3B3	1.797	1.830	1.873

Effect of different Oat flour levels on Ash of low calorie fiber enriched herbal Gulabjamun

The mean value of ash (1.873) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of ash (1.873) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% Oat flour. While the minimum mean value of ash (1.197) was obtained when it was prepare with 10% Oat flour and it was found non-significant (Table 10). The ash content of *Gulabjamun* was significantly lower as the per cent addition of wheat bran increased there is significant decrease in ash content. This may be due to wheat bran contents 20 per cent minerals [11].

Effect of different Tulsi extract levels on Ash of low calorie fiber enriched herbal Gulabjamun

The mean value of ash (1.873) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of ash (1.873) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% *Tulsi* extract. While the minimum mean value of ash (1.197) was obtained when it was prepare with 10% *Tulsi* extract and it was found non-significant (Table 10).

Interactional effect of Sorbitol, Oat flour and Tulsi extract on Ash of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the Ash content of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of ash (1.873) has been obtained with $A_3 \times B_3 \times C_3$which was statistically at par with A×B×C significance level is 0.0000 which shows 0.01 level of significance, since the value obtained is 0.0 (**Table 11**).The minimum mean value of ash(1.197) obtained with different combinations of Sorbitol, Oat flour and *Tulsi* extract. The mean ash values have been shown graphically in **Figure 5**.

Table 11 ANOVA table for Ash w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	0.116	0.116	38.667	0.0000
Factor A	2	0.327	0.164	51.806	0.0000
Factor B	2	1.937	0.969	306.773	0.0000
Factor A × B	4	0.107	0.027	8.450	0.0000
Factor C	2	0.288	0.144	45.568	0.0000
Factor A × C	4	0.010	0.002	0.760	0.5560
Factor B × C	4	0.086	0.022	6.829	0.0002
Factor A×B×C	8	0.053	0.007	2.103	0.0000
Error	54	0.171	0.003		
Total	80	2.979			

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.0316. The standard error difference of two means was 0.0447. The critical difference (CD) of the combinations of these three different combinations obtained was 0.322 (**Table 12**). The Ash content values of combination of Sorbitol, Oat flour and *Tulsi* extract were significant as compared to separately.

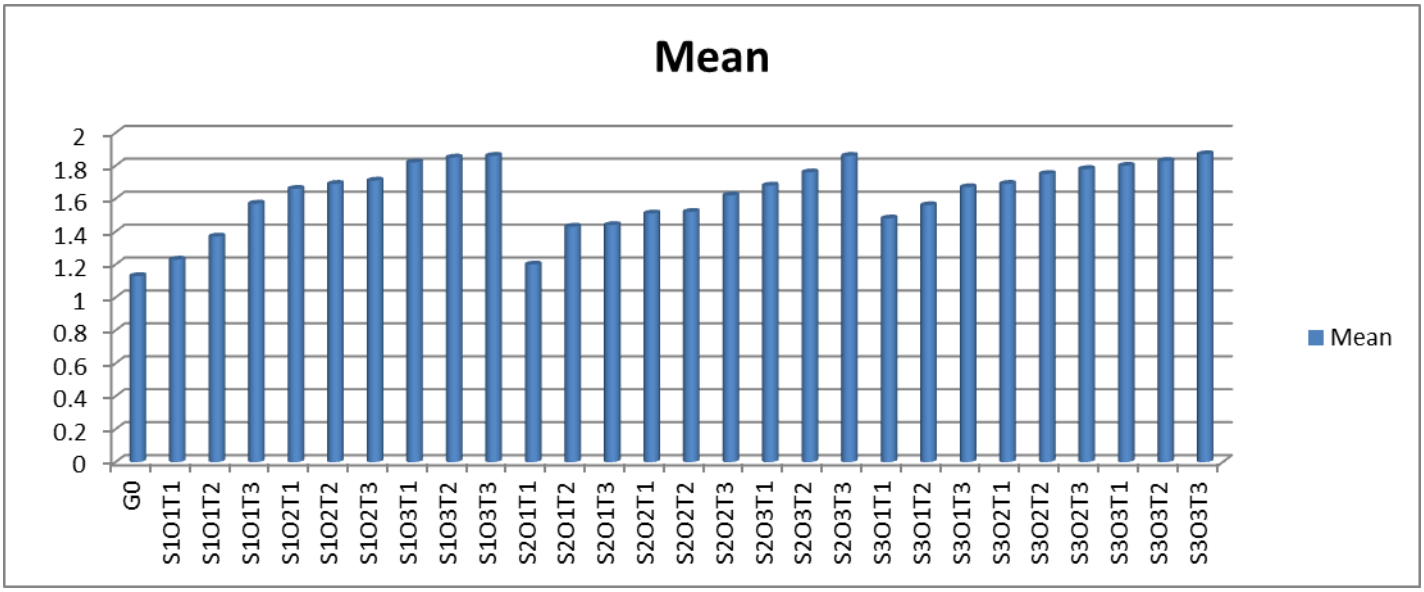

Figure 5 Mean Score Graph of Ashw.r. to different treatments

Table 12 SE (m), SE (d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0105	0.0105	0.0105	0.0182	0.0182	0.0182	0.0316	0.0071
SE (d)	0.0149	0.0149	0.0149	0.0258	0.0258	0.0258	0.0447	0.0100
CD	0.0300	0.0300	0.0300	0.0520	N.S.	0.0520	0.0322	0.0201

Total Sugar

Effect of different Sorbitol levels on Total Sugar of low calorie fiber enriched herbal Gulabjamun

The mean value of total sugar (54.390) of low calorie fiber enriched herbal *Gulabjamun* was significant when it was manufactured with 6% Sorbitol. The maximum mean value of total sugar (55.883) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 6% Sorbitol but different percentages of Oat flour and *Tulsi* extract. While the minimum mean value of total sugar (48.210) was obtained when it was prepare with 2% Sorbitol and it was found non-significant (**Table 13**).

Table 13 Mean Score of Total sugar w.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	50.043	50.047	49.890
A1B2	49.773	49.643	49.270
A1B3	48.903	48.550	48.210
A2B1	50.357	50.270	50.160
A2B2	49.860	49.680	49.520
A2B3	50.097	50.023	49.923
A3B1	55.883	55.767	55.597
A3B2	55.467	55.340	55.147
A3B3	54.780	54.560	54.390

Effect of different Oat flour levels on Total Sugar of low calorie fiber enriched herbal Gulabjamun

The mean value of total sugar (54.390) of low calorie fiber enriched herbal *Gulabjamun* was significant. This value was obtained when it was manufactured with 20% Oat flour. The maximum mean value of total sugar (55.883) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 10% Oat flour and it was non-significant. While the minimum mean value of total sugar (48.210) was obtained when it was prepare with 20% Oat flour and it was found non-significant when manufactured with different percentage of Sorbitol and *Tulsi* extract (Table 13).

Effect of different Tulsi extract levels on Total Sugar of low calorie fiber enriched herbal Gulabjamun

The mean value of total sugar (54.390) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of total sugar (55.883) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 10% *Tulsi* extract. While the minimum mean value of total sugar (48.210) was obtained when it was again prepared with 20% *Tulsi* extract but some other combinations of Sorbitol and Oat flour and it was found non-significant (Table 13).

Interactional effect of Sorbitol, Oat flour and Tulsi extract on Total Sugar of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the total sugar of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of total sugar (54.390) has been obtained with $A_3 \times B_3 \times C_3$which was statistically at par with A×B×C significance level is 0.0064 which shows 0.01 level of significance (**Table 14**).The minimum mean value of total sugar (48.210) obtained with different combination. The historical graph in **Figure 6** shows the mean total sugar values.

Table 14 ANOVA table for Total sugar w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	238.869	238.869	39811.500	0.0000
Factor A	2	556.688	278.344	43725.273	0.0000
Factor B	2	12.234	6.117	960.955	0.0000
Factor A × B	4	5.406	1.352	212.318	0.0000
Factor C	2	1.547	0.773	121.500	0.0000
Factor A × C	4	0.125	0.031	4.909	0.0019
Factor B × C	4	0.156	0.039	6.136	0.0004
Factor A×B×C	8	0.156	0.020	3.068	0.0064
Error	54	0.344	0.006		
Total	80	576.656			

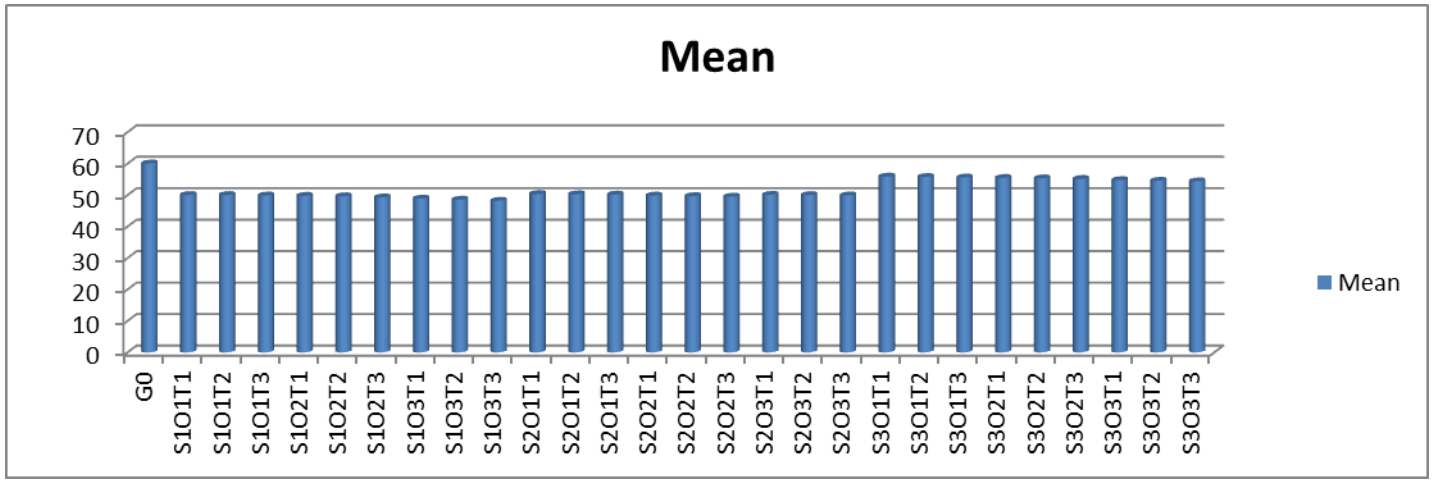

Figure 6 Mean Score Graph of Total sugarw.r. to different treatments

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.0447.The standard error difference of two means was 0.0632. The critical difference (CD) of the combinations of these three different combinations obtained was 0.1273 and were significantly in interaction with each other (**Table 15**).

Table 15 SE (m), SE (d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0149	0.0149	0.0149	0.0258	0.0258	0.0258	0.0447	0.0100
SE (d)	0.0211	0.0211	0.0211	0.0365	0.0365	0.0365	0.0632	0.0141
CD	0.0424	0.0424	0.0424	0.0735	0.0735	0.0735	0.1273	0.0285

Fiber

Effect of different Sorbitol levels on Fiber of low calorie fiber enriched herbal Gulabjamun

The mean value of fiber (3.857) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of fiber (3.857) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 6% Sorbitol. While the minimum mean value of fiber (2.157) was obtained when it was prepare with 2% Sorbitol and found non-significant (**Table 16**).

Table 16 Mean Score of Fiber contentw.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	2.157	2.300	2.347
A1B2	2.470	2.767	3.270
A1B3	3.553	3.650	3.840
A2B1	2.267	2.330	2.480
A2B2	2.580	2.650	2.713
A2B3	2.817	2.860	2.873
A3B1	2.463	2.730	2.907
A3B2	2.963	3.023	3.090
A3B3	3.353	3.597	3.857

Effect of different Oat flour levels on Fiber of low calorie fiber enriched herbal Gulabjamun

The mean value of fiber (3.857) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of fiber (3.857) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% Oat flour. While the minimum mean value of fiber (2.157) was obtained when it was prepare with 10% Oat flour was non-significant (Table 16). The results are in agreement with previous research worker [15] reported addition of wheat bran in *Gulabjamun* increased fibre content from 0.55 to 3.25 per cent.

Effect of different Tulsi Extract levels on Fiber of low calorie fiber enriched herbal Gulabjamun

The mean value of fiber (3.857) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of fiber (3.857) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% *Tulsi* extract. While the minimum mean value of fiber (2.157) was obtained when it was prepare with 10% *Tulsi* extract and this value was found non-significant (Table 16).

Interactional effect of Sorbitol, Oat flour and Tulsi extract on Fiber of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the fiber of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of fiber (3.857) has been obtained with $A_3 \times B_3 \times C_3$ which was statistically at par with A×B×C significance level is 0.0000 which shows 0.01 level of significance (**Table 17**).The minimum mean value of fiber (2.157) obtained with other different combinations. The graphical representation of mean value of fiber has been shown in **Figure 7**.

Table 17 ANOVA table for Fiber content w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	3.198	3.198	399.750	0.0000
Factor A	2	3.320	1.660	209.249	0.0000
Factor B	2	11.914	5.957	750.861	0.0000
Factor A × B	4	2.045	0.511	64.442	0.0000
Factor C	2	1.265	0.633	79.750	0.0000
Factor A × C	4	0.215	0.054	6.774	0.0002
Factor B × C	4	0.023	0.006	0.731	0.5748
Factor A×B×C	8	0.471	0.059	7.428	0.0000
Error	54	0.428	0.008		
Total	80	19.682			

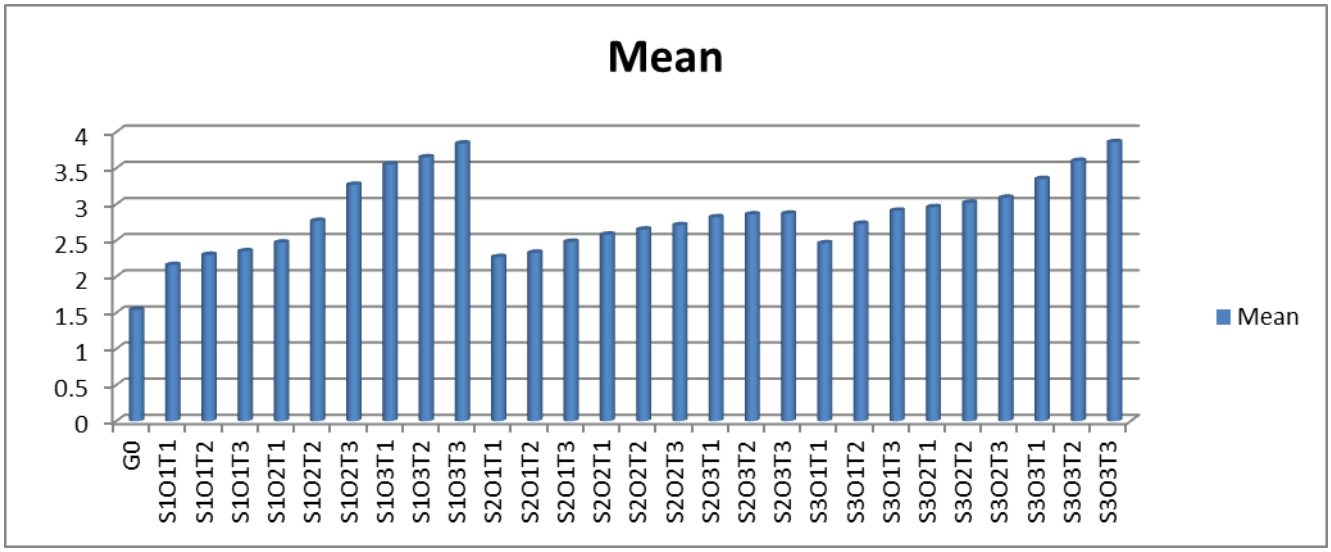

Figure 7 Mean Score Graph of Fiber content w.r. to different treatments

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.0516.The standard error difference of two means were 0.0730. The critical difference (CD) of the combinations of these three different combinations obtained was 0.1469 (**Table 18**). All the values in three combinations of Sorbitol, Oat flour and *Tulsi* extract were found significant.

Table 18 SE (m), SE (d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0172	0.0172	0.0172	0.0298	0.0298	0.0298	0.0516	0.0115
SE (d)	0.0243	0.0243	0.0243	0.0422	0.0422	0.0422	0.0730	0.0163
CD	0.0489	0.0489	0.0489	0.0849	0.0849	N.S.	0.1469	0.0329

DDPH (2, 2-diphenyl-1-picrylhydrazyl)

Effect of different Sorbitol levels on DDPH of low calorie fiber enriched herbal Gulabjamun

The mean value of DDPH (58.073) of low calorie fiber enriched herbal *Gulabjamun* was significant when it was prepared with 6% Sorbitol. The maximum mean value of DDPH (58.857) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 4% Sorbitol. While the minimum mean value of DDPH (40.230) was obtained when it was prepare with 2% Sorbitol and it was found significant (**Table 19**). The presence of antioxidants was also reported by [16].

Table 19 Mean Score of DPPH activity w.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	40.230	50.590	58.457
A1B2	40.570	52.500	58.203
A1B3	40.460	52.617	57.727
A2B1	41.707	53.383	58.287
A2B2	42.670	53.577	58.857
A2B3	42.490	53.717	57.777
A3B1	42.447	52.550	58.010
A3B2	42.373	53.023	58.023
A3B3	42.407	52.347	58.073

Effect of different Oat flour levels on DDPH of low calorie fiber enriched herbal Gulabjamun

The mean value of DDPH (58.073) of low calorie fiber enriched herbal *Gulabjamun* was significant when the product has been manufactured from 20% Oat flour. The maximum mean value of DDPH (58.857) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 15% Oat flour. While the minimum mean value

of DDPH (40.230) was obtained when it was prepared with 10% Oat flour and found non-significant (Table 19). [17] had also reported the antioxidant activity in Oat flour.

Effect of different Tulsi extract levels on DDPH of low calorie fiber enriched herbal Gulabjamun

The mean value of DDPH (58.073) of low calorie fiber enriched herbal Gulabjamun was significant when the maximum percentage of *Tulsi* extract has been incorporated in sugar syrup. The maximum mean value of DDPH (58.857) of low calorie fiber enriched herbal Gulabjamun was obtained when it was prepared with 20% *Tulsi* extract but found non-significant due to other different combinations of Oat and Sorbitol. While the minimum mean value of DDPH (40.230) was obtained when it was prepare with 10% i.e. minimum *Tulsi* extract (Table 19). The ethanolic extracts of Holy basil showed good heat stability and had high antioxidative stability [18].

Interactional effect of Sorbitol, Oat flour and Tulsi extract on DDPH of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the DDPH of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of DDPH (58.073) has been obtained with $A_3 \times B_3 \times C_3$which was statistically at par with A×B×C significance level is 0.0038 which shows 0.01 level of significance due to lesser value than 0.01 (**Table 20**). The minimum mean value of DDPH(40.230) obtained with different combinations of Sorbitol, *Tulsi* extract and Oat flour. The mean DDPH values have been shown graphically in **Figure 8**. The results shows agreement with [19].

Table 20 ANOVA table for DPPH activity w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	2623.145	2623.145	11454.782	0.0000
Factor A	2	21.812	10.906	47.711	0.0000
Factor B	2	2.859	1.430	6.254	0.0036
Factor A × B	4	1.031	0.258	1.128	0.3531
Factor C	2	3791.641	1895.820	8293.613	0.0000
Factor A × C	4	13.312	3.328	14.559	0.0000
Factor B × C	4	3.062	0.766	3.349	0.0160
Factor A×B×C	8	6.047	0.756	3.307	0.0038
Error	54	12.344	0.229		
Total	80	3852.109			

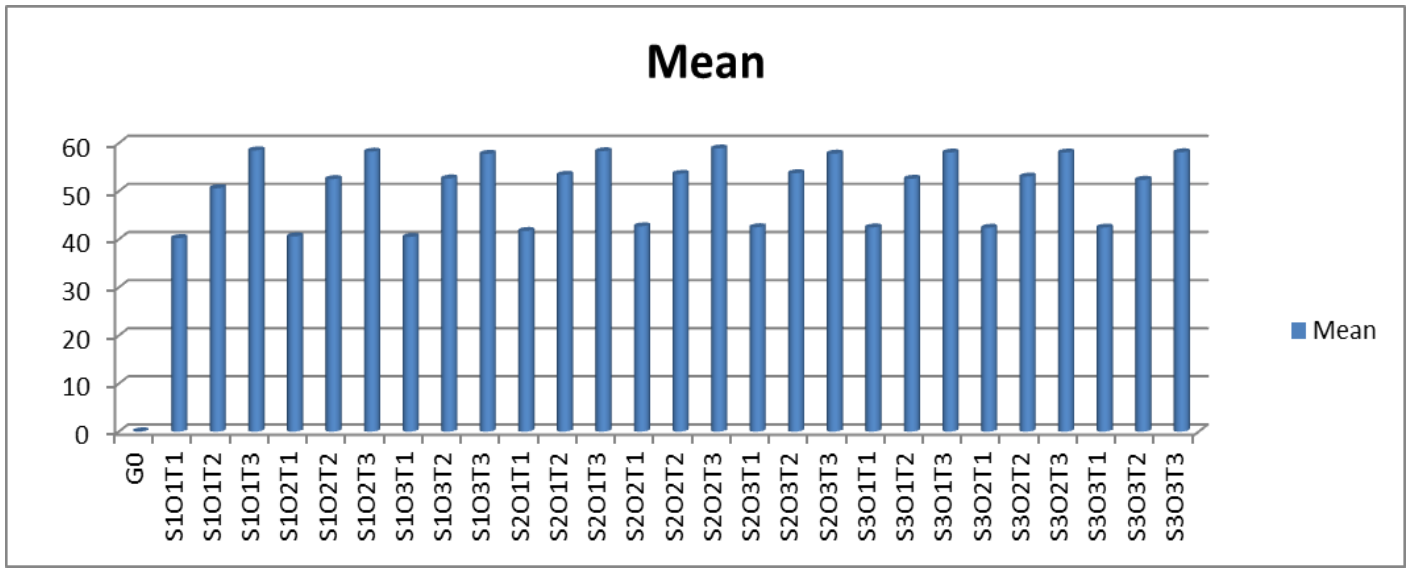

Figure 8 Mean Score Graph of DPPH activity w.r. to different treatments

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.2763.The standard error difference of two means were 0.3907. The critical differences (CD) of the combinations of these three different combinations obtained were 0.7864 and were significant (**Table 21**).

Table 21 SE (m), SE (d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0921	0.0921	0.0921	0.1595	0.1595	0.1595	0.2763	0.0617
SE (d)	0.1302	0.1302	0.1302	0.2255	0.2255	0.2255	0.3907	0.0873
CD	0.2621	0.2621	0.2621	N.S.	0.4540	0.4540	0.7864	0.1758

ABTS {2, 2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid)}

Effect of different Sorbitol levels on ABTS of low calorie fiber enriched herbal Gulabjamun

The mean value of ABTS (2.940) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of ABTS (2.940) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 6% Sorbitol. While the minimum mean value of ABTS (1.727) was obtained at when it was prepared with 2% Sorbitol which was found non-significant (**Table 22**). This is in favour with Mervat and Hanan (2009) [16].

Table 22 Mean Score of ABTS activity w.r. to different treatments

	C(1)	C(2)	C(3)
A1B1	1.840	1.933	2.890
A1B2	1.907	2.097	2.610
A1B3	1.727	1.930	2.670
A2B1	1.813	2.007	2.690
A2B2	1.860	2.357	2.930
A2B3	1.853	1.973	2.633
A3B1	1.853	2.133	2.683
A3B2	1.843	2.310	2.743
A3B3	1.917	2.240	2.940

Effect of different Oat flour levels on ABTS of low calorie fiber enriched herbal Gulabjamun

The mean value of ABTS (2.940) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of ABTS (2.940) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% Oat flour. While the minimum mean value of ABTS (1.727) was obtained when it was prepared with 20% Oat flour was non-significant (Table 22). Antioxidant properties in the form of Vitamin E have been reported by [20].

Effect of different Tulsi extract levels on ABTS of low calorie fiber enriched herbal Gulabjamun

The mean value of ABTS (2.940) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of ABTS (2.940) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% *Tulsi* extract. While the minimum mean value of ABTS (1.727) was obtained when it was prepared with 10% *Tulsi* extract. This value was found non-significant (Table 22).

Interactional effect of Sorbitol, Oat flour and Tulsi extract on ABTS of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the ABTS of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of ABTS (2.940) has been obtained with $A_3 \times B_3 \times C_3$which was statistically at par with A×B×C significance level is 0.0011 which shows 0.01 level of significance, since the combination value obtained was less than 0.01 (**Table 23**).The minimum mean value of ABTS (1.727) obtained with different other combinations. The historical graph in **Figure 9** shows the mean ABTS values. The same types of results were also observed by [19].

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 0.0730.The standard error difference of two means was 0.1033. The critical difference (CD) of the combinations of these three different combinations obtained was 0.0821 (**Table 24**). The values in combination of Sorbitol, Oat flour and *Tulsi* extract were in significant relationship as compared to the values separately.

Total Phenol

Effect of different Sorbitol levels on Total Phenol of low calorie fiber enriched herbal Gulabjamun

The mean value of total phenol (354.333) of low calorie fiber enriched herbal *Gulabjamun* was significant. The

maximum mean value of total phenol (354.333) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 6% Sorbitol. While the minimum mean value of total phenol (234.333) was obtained when it was prepared with 2% Sorbitol and was found non-significant (**Table 25**). Same type was results were also observed by [16].

Table 23 ANOVA table for ABTS activity w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	11.373	11.373	710.813	0.0000
Factor A	2	0.187	0.094	5.927	0.0047
Factor B	2	0.140	0.070	4.433	0.0165
Factor A × B	4	0.310	0.078	4.908	0.0019
Factor C	2	11.802	5.901	373.477	0.0000
Factor A × C	4	0.104	0.026	1.645	0.1764
Factor B × C	4	0.157	0.039	2.485	0.0542
Factor A×B×C	8	0.216	0.027	1.706	0.0011
Error	54	0.853	0.016		
Total	80	13.769			

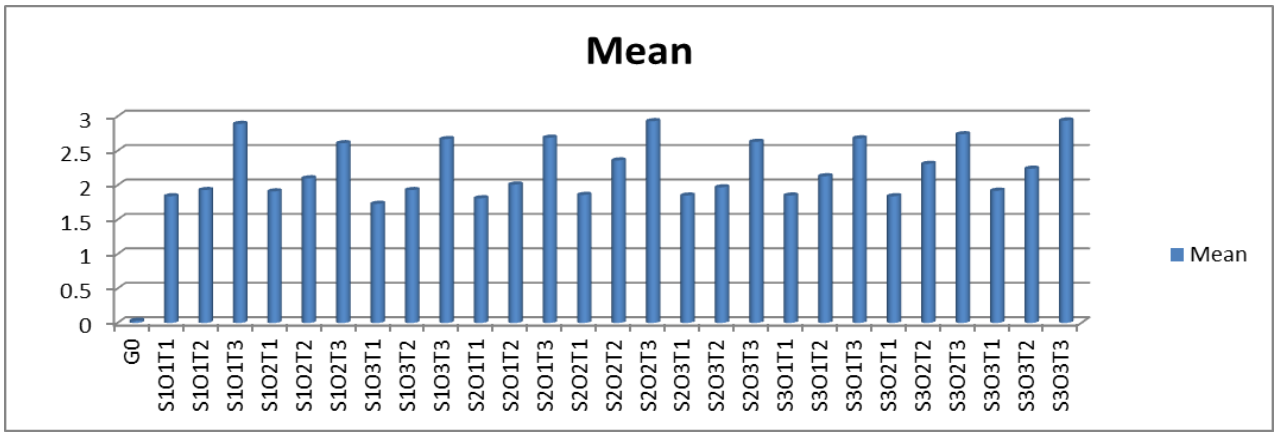

Figure 9 Mean Score Graph of ABTS activity w.r. to different treatments

Table 24 SE(M), SE(d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	0.0243	0.0243	0.0243	0.0422	0.0422	0.0422	0.0730	0.0163
SE (d)	0.0344	0.0344	0.0344	0.0596	0.0596	0.0596	0.1033	0.0231
CD	0.0693	0.0693	0.0693	0.1200	N.S.	N.S.	0.0821	0.0465

Table 25 Mean Score of Total Phenol content w.r. to different treatments

	C(1)	**C(2)**	**C(3)**
A1B1	234.333	272.667	311.000
A1B2	237.333	287.333	335.667
A1B3	245.667	290.333	343.000
A2B1	240.000	293.667	342.333
A2B2	235.667	284.667	353.333
A2B3	250.000	285.000	345.333
A3B1	240.667	277.333	327.667
A3B2	245.333	293.667	345.000
A3B3	247.333	287.000	354.333

Effect of different Oat flour levels on Total Phenol of low calorie fiber enriched herbal Gulabjamun

The mean value of total phenol (354.333) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of total phenol (354.333) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% Oat. While the minimum mean value of total phenol (234.333) which was non-significant

was obtained when it was prepared with 10% Oat flour (Table 25). The presence of phenolic component has been reported by [21].

Effect of different Tulsi extract levels on Total Phenol of low calorie fiber enriched herbal Gulabjamun

The mean value of total phenol (354.333) of low calorie fiber enriched herbal *Gulabjamun* was significant. The maximum mean value of total phenol (354.333) of low calorie fiber enriched herbal *Gulabjamun* was obtained when it was prepared with 20% *Tulsi* extract. While the minimum mean value of total phenol (234.333) was obtained when it was prepare with 10% *Tulsi* extract and this value was found to be non-significant (Table 25). [22] isolated the antioxidant principles of *Tulsi* (*Ocimum sanctum* Linn.) leaves via a pre-extraction. The anti-oxygenic compounds of *Tulsi* leaves were extracted into methanol and then vacuum dried. The dried materials were further fractionated into water insoluble fraction which was then treated with mixture of silica gel and charcoal and designated at SCF. Addition of SCF pre-extract at the level of 0.6 percent (w/v) was found to be more effective than the addition of BHA at the level of 0.02 per cent. The phenolic compounds appeared to be the main contributory factors in enhancing the oxidative stability of the developed product.

Interactional effect of Sorbitol, Oat flour and Tulsi extract on Total Phenol of low calorie fiber enriched herbal Gulabjamun

Treatment combination of Sorbitol, Oat flour and *Tulsi* extract significantly influenced the total phenol of low calorie fiber enriched herbal *Gulabjamun*. The best mean value of total phenol (354.333) has been obtained with $A_3 \times B_3 \times C_3$combination $_{which}$ was statistically at par with A×B×C significance level is 0.0032. Due to lesser value than 0.01, $A_3 \times B_3 \times C_3$combinationhas0.01 significance level (**Table 26**).The minimum mean value of total phenol (234.333) obtained with other different combinations. The graphical representation of mean value of total phenol has been shown in **Figure 10**. [23] has also reported the higher percentage of antioxidant activity and phenolic component in Tulsi.

Table 26 ANOVA table for Total Phenol content w.r. to different treatments combinations

Source	D.F	S.S	M.S.S	F-cal	Significance
Cont V/S Treat	1	133177.841	133177.841	645.451	0.0000
Factor A	2	1015.000	507.500	2.460	0.0950
Factor B	2	2086.000	1043.000	5.055	0.0097
Factor A × B	4	1004.500	251.125	1.217	0.3143
Factor C	2	129914.500	64957.250	314.817	0.0000
Factor A × C	4	607.000	151.750	0.735	0.5718
Factor B × C	4	892.500	223.125	1.081	0.3749
Factor A×B×C	8	695.500	86.938	0.421	0.0032
Error	54	11142.000	206.333		
Total	80	147357.000			

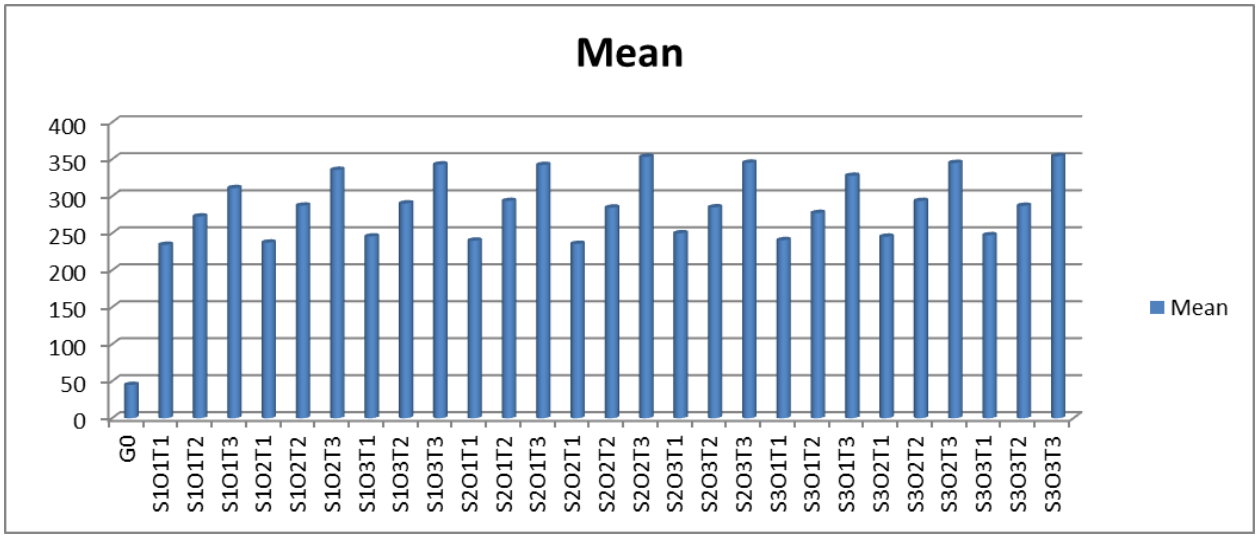

Figure 10 Mean Score Graph of Total Phenol w.r. to different treatments

The standard error means SE (m) of Sorbitol, Oat flour and *Tulsi* extract combinations were 8.2932.The standard error difference of two means was 11.7266. The critical difference (CD) of the combinations of these three different combinations obtained was 10.2551 (**Table 27**). The values for combinations of A×B×C have significant relationship as compared with other combinations or separately.

Table 27 SE(M), SE(d) and CD table

	A	B	C	A×B	A×C	B×C	A×B×C	C/T
SE (m)	2.7644	2.7644	2.7644	4.7881	4.7881	4.7881	8.2932	1.8539
SE (d)	3.9089	3.9089	3.9089	6.7704	6.7704	6.7704	11.7266	2.6214
CD	N.S.	7.8686	7.8686	N.S.	N.S.	N.S.	10.2551	5.2765

Summary and Conclusion

The optimization has been also been done on the basis of chemical analysis. The mean score of chemical properties evaluated of the optimized product were as follows and found significantly different with the control one.

- Moisture - 30.19%
- Fat - 11.41%
- Protein - 9.07%
- Ash - 1.87%
- Total sugar - 54.39%
- Fiber content - 3.85%
- DPPH activity - 58.07
- ABTS activity - 2.94
- Total Phenol content - 354.33

The results showed that the developed low calorie, fiber enriched herbal *Gulabjamun* possesses higher antioxidant activity and have considerable amount of total phenolic components due to presence of *Tulsi* extract in the sugar syrup which is used to dip the *Gulabjamun* Balls.

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