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Studies on rheological parameters of *Gulabjamun* blended with coconut and wheat bran

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Abstract
In present investigation preparation of *gulabjamun* blended coconut and wheat bran with different percent *i.e.* T_1 (Control), T_2 (2% WB), T_3 (3% WB), T_4 (15% C), T_5 (20% C) and T_6 (2% WB + 20% C) studied rheological parameters of *gulabjamun* such as hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness. Texture profile analysis of product revealed that the hardness of *gulabjamun* for treatments T_1, T_2, T_3, T_4, T_5 and T_6 were 25.001, 57.662, 22.903, 84.701, 101.072 and 106.297 N, respectively. The treatment T_6 show highest hardness (106.297 N) and treatment T_3 show lowest hardness of *gulabjamun* (22.903 N), addition of wheat bran reduces the hardness of *gulabjamun*. The treatment T_3 show highest cohesiveness (0.65), Addition of wheat bran causes stickiness in products it helps to increases in cohesiveness of *gulabjamun.* The treatment T_1 show lowest adhesiveness of *gulabjamun* (0.086 Nmm), adhesiveness is related to the sensory stickiness and indicated by a negative peak following the first peak. The treatment T_6 show highest springiness of *gulabjamun* (23.07 mm), the springiness depends on factors such as heat treatment and degree of firmness. The treatment T_5 show highest gumminess (59.578 N) and treatment T_3 had lowest gumminess of *gulabjamun* (14.694 N). As coconut level increases gumminess of products get increased. The treatment T_5 show highest chewiness (1350.00 N mm) and treatment T_3 had lowest chewiness of *gulabjamun* (211.59 Nmm). The addition of wheat bran and coconut significantly affected the chewiness of *gulabjamun.* The treatment T_3 (3% WB) show highest score for cohesiveness and lowest score for hardness, springiness, gumminess and chewiness due to high concentration of wheat bran in that *gulabjamun*.

Keywords: Gulabjamun, rheological parameters, wheat bran and coconut

Introduction
Gulabjamun occupies unique place in the array of Indian sweets (Aneja, 1992) [3]. *Gulabjamun* is a popular *khoa* based sweet and originally it was made with *khoa* and maida. It got the name of *Gulabjamun* as it looks like monsoon fruit "Jamun" and is flavoured with "rose water". *Dhap khoa* having 40-45 percent moisture is normally used for its preparation. *Gulabjamun* is largely produce by manual operation which adopts small scale batch method. It is generally prepared from the cow or buffalo milk *khoa* by kneading with wheat flour (maida) and baking powder to form smooth dough, portioning the dough, rolling them into balls of spherical shape, deep frying the balls in oil till they turn golden brown in colour and soaking them in the sugar syrup for overnight (Nalawade *et al*., 2015) [11]. Though there is large variation in the sensory quality of *gulabjamun*, the most liked product should have brown colour, smooth and spherical shape, soft and slightly spongy body free from both lumps and hard central core, uniform granular texture, mildly cooked and oily flavor, free from doughy feel and fully succulent with sugar syrup. It should have optimum sweetness. The gross chemical composition of *gulabjamun* varies widely depending on numerous factors, such as composition and quality of *khoa*, proportion of ingredients and sugar syrup concentration, *etc*. The composition of *gulabjamun*, on the drained weight basis, varies as: moisture (25–35%), fat (8.5–10.5%), protein (6 –7.6%), ash (0.9–1.0%) and total carbohydrates (43–48%) (Minhas *et al.* 1985) [9]. 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 (Naikwadi *et al.*, 2010) [10]. The texture of *gulabjamun* is judged mainly on its sponginess and juiciness, with crumbliness and gumminess being the main negative attributes (Ghosh *et al*., 1986 and Patel *et al.*, 1992) [6, 12].

Fresh coconut kernel contains: moisture (50%), oil (34%), ash (2.2%), fibre (3.0%), protein (3.5%) and carbohydrate (7.3%). Coconut oil is produced by crushing copra, the dried kernel, which contains about 60-65% of the oil. The oil has the natural sweet taste of coconut and contains 92 percent of saturated fatty acids (in the form of triglycerides). Coconut oil has a long shelf life and is used in baking industries, processed foods, pharmaceuticals, cosmetics and as hair oil. Coconut often called as 'Tree of life', is a valuable fruit tree in the world, especially in the tropical and subtropical regions. Fresh mature coconut is an excellent source of minerals such as copper, calcium, iron, manganese, magnesium and zinc, and a very good source of vitamin B complex such as folates, riboflavin, niacin, thiamine and pyridoxine. These MUFAs do not participate in the biosynthesis and transport of cholesterol as they are directly absorbed from the intestine and passed on to liver to be rapidly metabolized for energy production (Enig, 2004) [5].

Wheat is most important staple food for more than 1/3 rd of the world human population and it is considered as good source of protein, minerals, B-group vitamins and dietary fiber. Wheat bran is generally discarded product in the milling of the flour. The wheat bran is good source of B-complex vitamins (riboflavin, niacin and thiamine), trace minerals (Ca, K, P, Mg and Niacin) in small quantities and indigestible cellulose (Kumar *et al.*, 2011) [8]. Wheat bran is more wholesome and nourishing than flour itself. It is an excellent laxative and its laxative effect is much more superior to those of fruits or vegetables because cellulose of later is more easily broken by bacteria in intestine. Wheat bran is used as supplement source of dietary fiber for prevention of colon diseases, gastric cancer, type 2 diabetes, constipation *etc*. It is also helps in easy execution of faeces due to increased peristalsis. It is well known that milk is not a good source of iron and fiber. Therefore, incorporation of wheat as an ingredient in dairy products would help in alleviating its nutritional value.

Now a days, dietary fiber is gaining more importance in human diet due to its important role in human health. According to WHO, requirement of dietary fiber is 23-27 g/day and as per National Institute of Food Nutrient, it is 40-50 gm/day. Most of dietary fiber consumed by people in the form of cereal, vegetables and fruits. Incorporation of plant origin material in milk or milk products, directly or indirectly adds dietary fiber in human food. So far the research on incorporation of plant and fruit origin materials in milk and milk products has been focused on value addition to improve acceptability, taste, flavor development and as thickening agent. Therefore, there is obvious need to supplementing the milk with a necessary micronutrients and health promoting components from suitable sources. In recent years, cereals and its ingredients are accepted as functional food and nutraceuticals because of providing dietary fiber, proteins, energy, minerals, vitamins, and antioxidants required for human health. So that, taking into account of nutritional values of coconut and wheat bran, the present research was planned to prepare *gulabjamun* with blends of different level of coconut and wheat bran.

Materials and Methods

Standardization of milk

Cow milk obtained from the Research cum Development project on Cattle (RCDP) was used for obtaining *khoa*. Milk was standardized to 4.0% fat and 8.5% solids-not-fat (SNF).The standardized milk was converted to *khoa* by heat desiccation method in an open steam jacketed kettle.

Preparation of *khoa*

Khoa was preparing as per the standard procedure given by Rangi *et al.* (1985) [13].

Preparation of grated coconut

First black skin of wet coconut fruit was removed, followed by grating of coconut. A small quantity of water was added in grated coconut and it was allow soaking for 20 minutes. Water soaked grated coconut was blended with the help of mixer for one minute. The grated coconut paste prepared was used in different combinations with cow milk for *gulabjamun* preparation.

Preparation of sugar syrup

The syrup was prepare by dissolving sugar in water in the proportion of 1:1 and kept for boiling for 10 to 15 minutes. Any dirt or impurity that gathers on the surface of the syrup during boiling was removed with ladle. The syrup was ready when sugar concentration reached 60^0 Brix.

Phase I: Preliminary trials

Preliminary trials were conducted to finalize the levels of coconut and wheat bran in *gulabjamun*. The samples of product were subjected to sensory evaluation. On the basis of the results of sensory evaluation, treatments were finalized for experimental trials. The most accepted sugar level was selected and kept constant for further experimental trials.

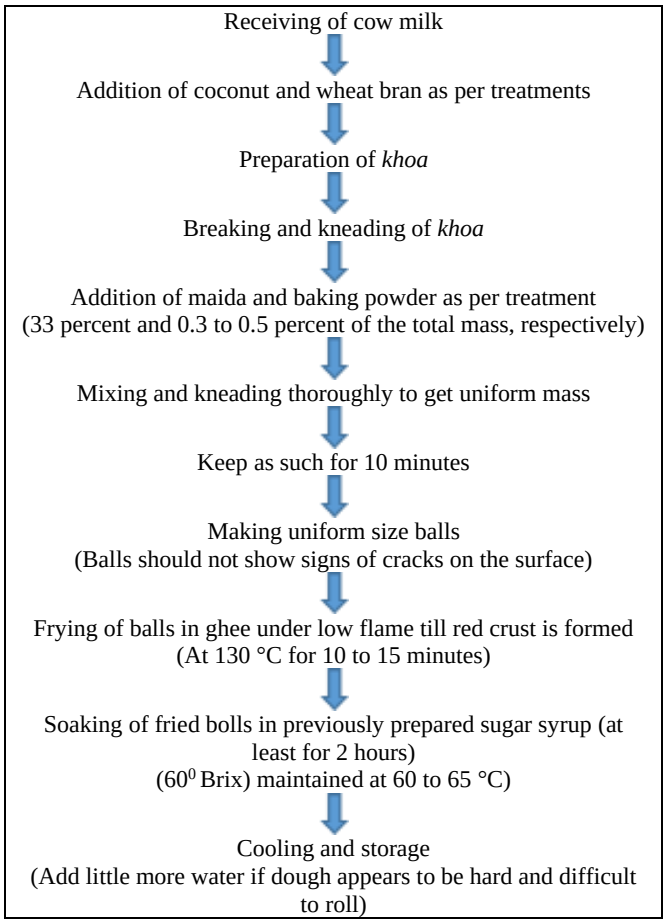
Phase II: Experimental trials

Optimization of levels of coconut and wheat bran in preparation of *Gulabjamun*

In preliminary trials, acceptability of extent of wheat bran and coconut level were tried as 1, 2, 3, 4 and 5 percent for wheat bran and 5, 10, 15, 20, 25 percent for coconut in desired product. On the basis of results of sensory evaluation, most acceptable level of wheat bran (2 and 3%) and coconut (15 and 20%) and combination (2+20) percent with constant sugar syrup of 60^0 brix was selected for final experimental trials. The most accepted 60^0 brix sugar syrup was constant for all the treatments in final experimental trial. The *gulabjamun* prepared with different treatment combinations were studied as below;

Preparation of *Gulabjamun*

Gulabjamun was prepared as per the procedure given by Srinivasan and Anantkrishnan (1964) [14] with slight modifications as per flow diagram given below:-



Sugar syrup absorption

Fried *gulabjamun* balls (two for each treatment) with known weight was transferred to 50 ml beaker containing sugar syrup (60^0 Brix), and allowed to soak for overnight at room temperature. *Gulabjamun*, after removing from syrup was allowed to drain for 10 min. on wire gauge and then weighed. Increase in weight of two *gulabjamun* over initial weight was taken as the amount of sugar syrup absorbed by *gulabjamun* and represented as percentage absorption of sugar syrup.

Texture profile analysis of Gulabjanun blended with coconut and wheat bran

Texture is an important attribute of *gulabjamun* that contributes in deciding the acceptability by the consumers. Stable Micro System TAXT2i Texture Analyzer (Mode TPA2) was used for texture profile analysis (TPA) of *gulabjamun* was taken at different stage. A P36 R cylindrical probe with 5 mm/s and 50 percent compression was taken for TPA analysis. TPA is "two bite" test, which includes first and second compression cycles indicate the force *vs*. time data during first and second compression of product by the instrumental probe. Various textural characteristics such as, hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness. The textural parameters of *gulabjamun* was determine by using following points.

Hardness

It was defined as the value of the peak force of the first compression of the product.

Hardness, N (H) = Maximum force of first compression.

Cohesiveness

Extent to which a material can be deformed before it ruptures depending on the strength of internal bonds. (Ratio of the positive force areas under first and second compressions).

$$\text{Cohesiveness} = \frac{\text{Area under the } 2^{nd} \text{ compression } (A_2)}{\text{Area under the } 1^{st} \text{ compression } (A_1)}$$

Adhesiveness: Force necessary to remove the material that adheres to the mouth when eating food.

Adhesiveness, Nmm (A_3) = Negative area in the gap

Springiness (mm)

Height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite.

Gumminess

Energy required disintegrating a semi-solid food product to a state ready for swallowing.

Gumminess (N) = Hardness x Cohesiveness

Chewiness

Energy required for masticating a solid food product to make it ready for swallowing.

Chewiness, Nmm (Cw) = Hardness x Springiness

Results and discussion

The results of the present investigation are presented and discussed here under following headings.

Rheological parameter of *Gulabjamun* blended with coconut and wheat bran

The samples of *gulabjamun* were subjected to rheological parameter for hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness by using TPA (Texture Profile Analyzer). The changes in rheological properties of *gulabjamun* blended with coconut and wheat bran have a direct bearing on the acceptance of the product, which signifies its importance.

Table 1: Description of values obtained by textural analysis of *Gulabjamun* blended with coconut and wheat bran

Treatments	Peak Positive Force (Cycle 1) g	Positive Area Cycle 1 (A_1) g.sec	Positive Area Cycle 2 (A_2) g.sec	Negative Area Cycle 1 (A_3) g.sec	Distance from start to peak cycle 2 (mm)
T_1	25.001	16.981	10.089	0.086	9.99
T_2	57.662	40.531	22.635	0.353	10.00
T_3	22.903	43.162	28.131	0.746	9.99
T_4	84.701	65.137	32.443	0.179	9.99
T_5	101.072	74.273	43.496	0.300	9.99
T_6	106.297	141.535	36.489	1.219	9.99

Table 2: Textural parameters of *Gulabjamun* blended with coconut and wheat bran

Treatments	Hardness (H) (N)	Cohesiveness (A_1/ A_2)	Adhesiveness (A_3) Nmm	Springiness (D_1) (mm)	Gumminess (H x A_1/ A_2) (N)	Chewiness (H x A_1/ A_2 x D_1) Nmm
T_1	25.001	0.59	0.086	18.25	15.036	274.40
T_2	57.662	0.55	0.353	14.96	31.460	470.64
T_3	22.903	0.65	0.746	14.40	14.694	211.59
T_4	84.701	0.49	0.179	20.31	41.400	840.83
T_5	101.072	0.58	0.300	22.66	59.578	1350.00
T_6	106.297	0.25	1.219	23.07	26.540	612.27

Hardness

From given Table no. 2, it was clear that the hardness score obtained for different treatment combination was ranged from 25.001 to 106.297 N. Treatment T_6 obtained highest score (106.297 N) for hardness of *gulabjamun* while T_3 obtained lowest score of 22.903 N). This was due to higher level of wheat bran added into *gulabjamun* resulted into decreasing hardness. As coconut level increases hardness increases. The results obtained in present study agreed with Adhikari *et al*. (1994) [2], reported that the hardness of market sample of *gulabjamun* was 11.60±1.35 N, whereas, the hardness of laboratory sample of *gulabjamun* was 9.80±1.10 N. Chaudhari (2016) [4], reported that the average values of hardness of *gulabjamun* made from different rate moraiyo was ranging from 5.10 to 8.16 N.

Cohesiveness

It was clear that the cohesiveness score obtained for different treatment combination was ranged from 0.25 to 0.65. Treatment T_3 obtained highest score (0.65) for cohesiveness while T_6 obtained lowest score (0.25) for cohesiveness of *gulabjamun*. Chaudhari (2016) [4], reported that the averages of cohesiveness experimental *gulabjamun* were ranged from 0.18 to 0.25.

Adhesiveness

The adhesiveness score obtained for different treatment combination was ranged from 0.086 to 1.219 Nmm. Treatment T_6 obtained highest adhesiveness score 1.219 Nmm of *gulabjamun* and T_1 obtained lowest score 0.086 Nmm of *gulabjamun*. The results obtained in present study found agreed with Adhikari *et al*. (1994) [2], investigated interrelationship among texture, composition and microstructure of buffalo milk *khoa* and *gulabjamun*. The adhesiveness of market sample of *gulabjamun* was found to be 0.60±0.08 Nmm, whereas the adhesiveness of laboratory sample of *gulabjamun* was 0.50±0.06 Nmm.

Springiness

The springiness score obtained for different treatment combination was ranged from 14.40 to 23.07 mm of *gulabjamun* blended with coconut and wheat bran. The results observed in the present study corroborates with those reported in literature, Yawale and Rao (2012) [16], examined textural profile analysis of effect of maida level in *khoa* powder *gulabjamun* mix and mentioned that the increase the level of maida increased the springiness of *gulabjamun*. Chaudhari (2016) [4], reported that the average springiness of experimental *gulabjamun* was ranged from 6.64 to 8.19 mm.

Gumminess

The gumminess score obtained for different treatment combination was ranged from 14.694 to 59.578 N of *gulabjamun* blended with coconut and wheat bran. Treatment T_5 obtained highest score (59.578 N) for gumminess while T_3 obtained lowest score (14.694 N) for gumminess of *gulabjamun*. The results observed in the present study finds with those reported as Ghube *et al.* (2015) [7], examined the textural characteristic of *gulabjamun* made from *khoa* blended with wheat bran and reported that gumminess decreased with increase in the rate of wheat bran. Adhikari (1993) [1] investigated the textural characteristic of *khoa* and *gulabjamun* made from cow milk reported that gumminess of laboratory and market sample *gulabjamun* was 0.35 and 0.39 N. Yawale and Rao (2012) [16], studied textural profile analysis of effect of maida level in *khoa* powder *gulabjamun* mix and reported the gumminess ranged from 0.25 to 0.30 N. Chaudhari (2016) [4], reported that the average gumminess of experimental *gulabjamun* was ranged from 0.93 to 2.11 N.

Chewiness

The chewiness score obtained for different treatment combination was ranged from 211.59 to 1350 Nmm of *gulabjamun* blended with coconut and wheat bran. Treatment T_5 obtained highest score (1350.00 Nmm) for chewiness while T_3 obtained lowest score (211.59) Nmm of *gulabjamun.* This results agreement with Vasava *et al.*, (2018) [15], was observed that the average values for chewiness for different samples of gluten-free of *gulabjamun* were found to vary from 5.02 (P_1S_3) to 11.93 Nmm (P_2S_2). Adhikari *et al.* (1994) [2], reported that the chewiness of market sample of *gulabjamun* was found to be 18.71±5.12 Nmm, whereas, the chewiness of laboratory sample of *gulabjamun* was 12.35±4.12 Nmm.

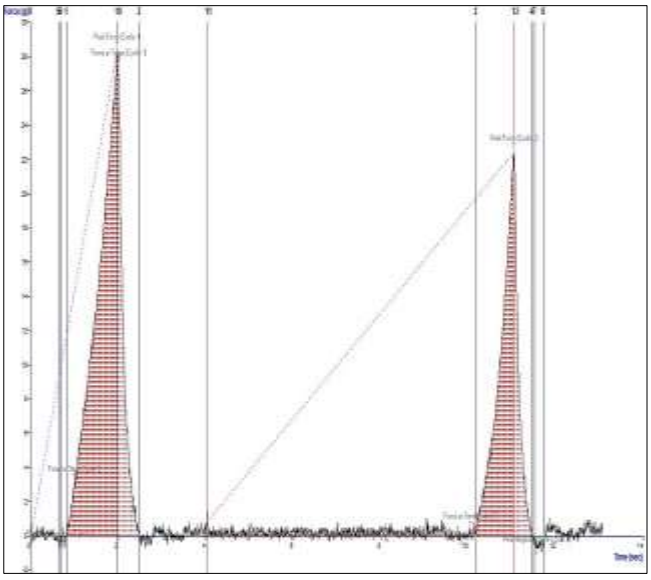


Fig 1: Representation of texture profile curve of Treatment T_1 (Control)

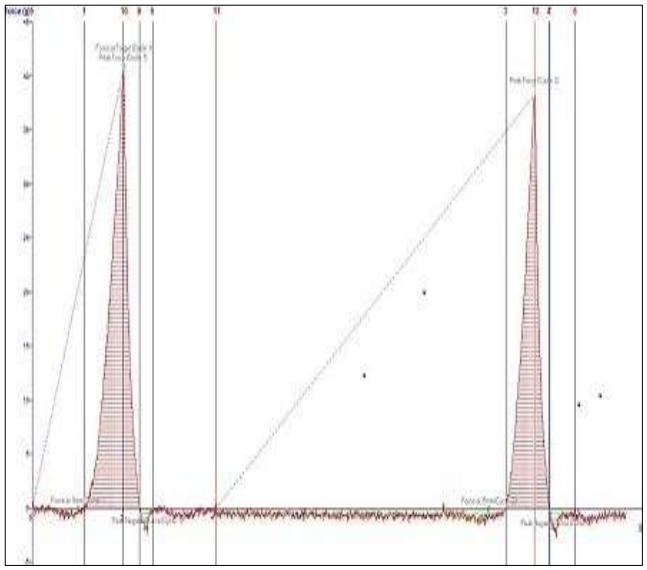


Fig 2: Representation of texture profile curve of Treatment T_2 (2% WB)

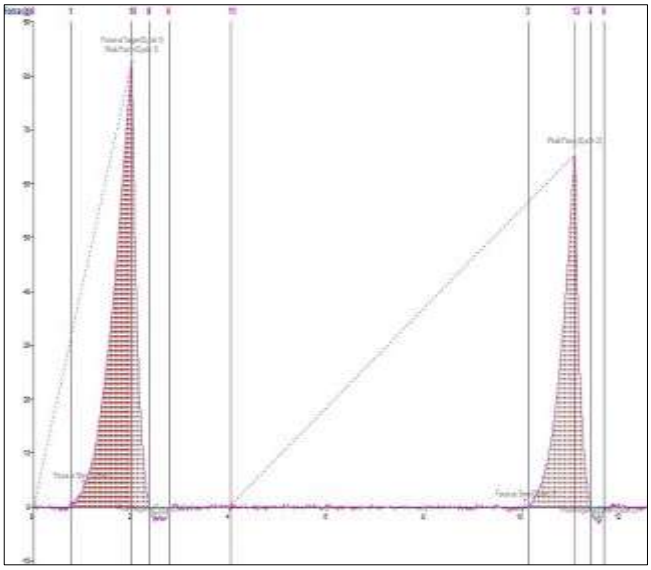


Fig 3: Representation of texture profile curve of Treatment T_3 (3% WB)

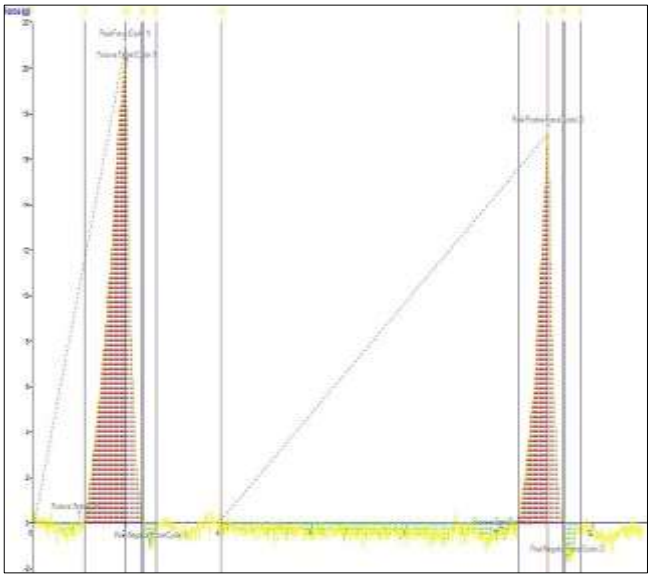


Fig 4: Representation of texture profile curve of Treatment T_4 (15% C)

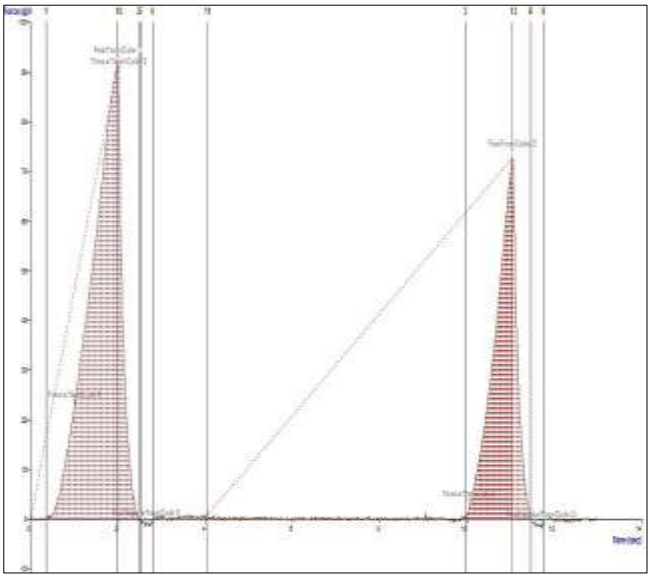


Fig 5: Representation of texture profile curve of Treatment T_5 (20% C)

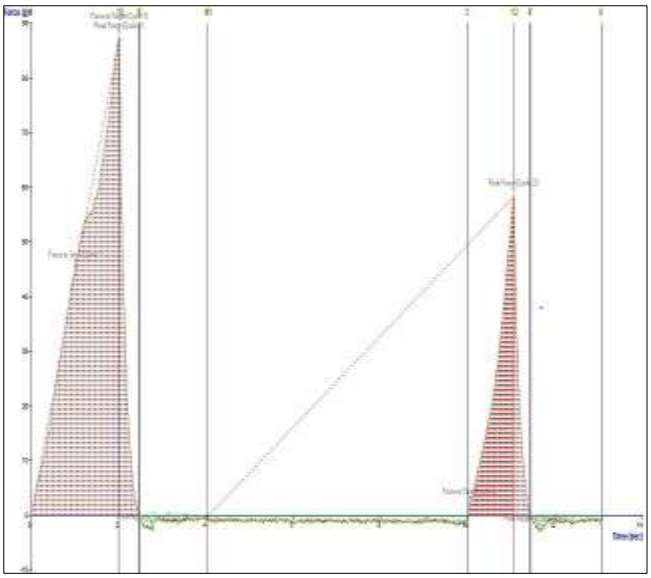


Fig 6: Representation of texture profile curve of Treatment T_6 (20% C+ 2% WB)

Conclusions

The hardness of *gulabjamun* for treatments T_1, T_2, T_3, T_4, T_5 and T_6 were 25.001, 57.662, 22.903, 84.701, 101.072 and 106.297 N respectively. The treatment T_6 show highest hardness (106.297 N) and treatment T_3 had lowest hardness (22.903 N). Addition of wheat bran reduces the hardness of *gulabjamun*. The treatment T_3 show highest cohesiveness (0.65) and treatment T_6 had lowest cohesiveness of *gulabjamun* (0.25). Addition of wheat bran causes stickiness in products it helps to increases in cohesiveness of *gulabjamun.* The treatment T_1 show highest adhesiveness (0.086 Nmm) and treatment T_6 had lowest adhesiveness of *gulabjamun* (1.219 Nmm). Adhesiveness is related to the sensory stickiness and indicated by a negative peak following the first peak. The treatment T_6 show highest springiness of *gulabjamun* (23.07 mm). The springiness depends on factors such as heat treatment and degree of firmness. The treatment T_5 show highest gumminess (59.578 N) and treatment T_3 had lowest gumminess of *gulabjamun* (14.694 N). As coconut level increases gumminess of products get increased. The

treatment T_5 show highest chewiness of *gulabjamun* (1350.00 Nmm) and treatment T_3 had lowest chewiness of *gulabjamun* (211.59 Nmm). The addition of wheat bran and coconut significantly affected the chewiness of *gulabjamun.* The textural parameter of *gulabjamun*, blended with coconut and wheat bran for treatment T_3 (3% WB) show highest score for cohesiveness and lowest score for hardness, springiness, gumminess and chewiness due to high concentration of wheat bran in that *gulabjamun*. The treatment T_4 show hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness found to be 84.701 N, 0.49, 0.179 Nmm, 20.31 mm, 41.400 N and 840.83 Nmm respectively. So that it revealed that *gulabjamun* prepared by adding 15 percent coconut was found to be best treatment in respect of rheological parameters of *gulabjamun*.

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