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Shubham Pachankar
M.Sc. Student, Department of Food Science and Nutrition, College of Community Science, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Kailash Gadhe
Associate Professor and Head, Department of Food Chemistry and Nutrition, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Ashwini Bidwe
Teaching Associate, Department of Food Science and Nutrition, College of Community Science, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Swati Pawar
M.Sc Student, Department of Food Science and Nutrition, College of Community Science, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
Shubham Pachankar
M.Sc. Student, Department of Food Science and Nutrition, College of Community Science, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Studies on standardization and quality evaluation of jaggery chocolate blended with flaxseed powder

Shubham Pachankar, Kailash Gadhe, Ashwini Bidwe and Swati Pawar

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Abstract
The study involved the standardization of chocolate by replacing sugar and cocoa butter with granular jaggery powder and flaxseed powder. Organoleptic evaluations indicated that the chocolate variation (T_3) with 17.5% granular jaggery powder and 12.5% flaxseed powder achieved the highest scores for color, flavor, texture, taste, and overall acceptability. Proximate analysis of the accepted chocolate revealed significant changes in moisture, ash, protein, carbohydrate, fiber, and fat content compared to the control chocolate. Mineral composition, nutraceuticals analysis (omega-3 and omega-6 fatty acid) content were assessed in both control and accepted chocolates the values are calcium (104.2±0.27 and 149.41±0.05 mg per 100 g), phosphorus (90.73±0.07 and 153.76±0.04 mg per 100 g), iron (3.06±0.03 and 5.10±0.01 mg per 100 g), copper (1.55±0.05 and 1.74±0.02 mg per 100 g), zinc (0.94±0.02 and 1.53±0.04 mg per 100 g), magnesium (0.69±0.03 and 52.65±0.06 mg per 100 g), omega-3 (93.45±0.02 and 1580.28±19.65 mg per 100 g) and omega-6 (296.66±0.05 and 373.26±14.3 mg per 100 g), respectively with demonstrating notable variations. Textural profile analysis highlighted differences in hardness, springiness, cohesiveness, and chewiness between the control chocolate and the preferred variation. Theoretical and total energy values were compared, showing a decrease in total energy value for the accepted chocolate.

Keywords: Flaxseed, granular jaggery, nutrients, chocolate, textural profile

Introduction

The trend in Indian food processing is increasingly focused on processing, preserving, and enhancing value. Value addition involves creating high-quality products through fortification and enrichment using functional ingredients. The confectionery sector stands out as one of the rapidly growing segments in the food processing industry. In today's fast-paced lifestyles, individuals seek nutritious snacks for health benefits and nourishment. Flaxseed, recognized for its rich content of omega-3 fatty acids, dietary fiber, lignans, and essential nutrients, has experienced a notable rise in its incorporation into value-added food products (Alpers and Sawyer-Morse, 1996; Gilbert, 2002) [2, 5]. Jaggery, often referred to as "medicinal sugar," finds applications in Ayurveda and shares similarities with honey (APEDA, 2016). Consequently, flaxseed and jaggery emerge as valuable functional ingredients for chocolate preparation, offering both nutritional and medicinal value.

The primary raw material used to make chocolate are cocoa beans, which are the seeds of the (*Theobroma cacao* L.) tree. Cocoa trees are found only in the geographical range of 10° on either side of equator mainly in Central America, the West Indies, South America, and Africa (Caligiani *et al.*, 2014) [4]. Criollo, Forastero, and Trinitario are the main varieties of cocoa beans and each has a unique chemical composition as well as textural and organoleptic characteristics (Zyzelewicz *et al.*, 2018) [17]. Chocolate, a widely consumed and beloved product globally, comes in three primary types: dark, milk, and white chocolate. These varieties differ in composition, with dark chocolate typically comprising sugar, cocoa butter, and cocoa liquor. Beyond flavor and texture, the categorization extends to regulations, as outlined by the European Council in 2000. The antioxidant properties of flavonoids present in cocoa contribute to the health benefits associated with chocolate consumption, such as cardiovascular health and potential neuroprotection (Caligiani *et al.*, 2014; Meng *et al.*, 2009) [4, 11].

Chocolate, as a versatile matrix, has been used to develop aesthetically pleasing, healthy, and convenient products in response to consumer demands. The incorporation of bioactive ingredients, such as omega-3 PUFAs, probiotics, phenolic extracts, vitamins, and minerals, has resulted in the creation of functional chocolates. These not only offer health benefits but also serve as preservatives, extending the shelf life of various foods (Konar *et al*., 2018) [10]. Jaggery comes in varying colour, from golden brown to dark brown. Its composition typically comprises 50 percent sucrose, 20 percent invert sugar, 20 percent moisture, and the rest consists of insoluble components like ash, protein, and bagasse fines. Jaggery is a rich source of vitamins, essential minerals, and protein. For every 100 grams of jaggery, you can find a range of minerals, including calcium (40-100 mg), magnesium (70-90 mg), potassium (1056 mg), phosphorus (20-90 mg), sodium (19-30 mg), iron (10-13 mg), manganese (0.2-0.5 mg), zinc (0.2-0.4 mg), copper (0.1-0.9 mg), and chloride (5.3 mg). It also contains vitamins, such as vitamin A (3.8 mg), vitamin B1 (0.01 mg), vitamin B2 (0.06 mg), vitamin B5 (0.01 mg), vitamin B6 (0.01 mg), vitamin C (7.00 mg), vitamin D2 (6.50 mg), vitamin E1 (11.30 mg), and vitamin PP (7.00 mg). Furthermore, it provides 280 mg of protein per 100 grams of jaggery. Another variety of jaggery, known as Gur, serves as a high-calorie sweetener enriched with minerals, protein, glucose, and fructose. Gur is considered a healthier option compared to white sugar. High-quality Gur contains more than 70 percent sucrose, less than 10 percent glucose and fructose, 5 percent minerals, 3 percent moisture, and accumulates a substantial amount of iron during its preparation in iron vessels, making it an ideal ingredient for healthier chocolate formulations (Pattnayak *et al*., 2004) [14].

Flaxseed, scientifically known as *Linum usitatissimum*, stands out as a potent plant-based source of omega-3 fatty acids, specifically alpha-linolenic acid (ALA). This unique composition contributes to flaxseed's potential health benefits, addressing conditions such as cardiovascular diseases, diabetes, obesity, and more. Flaxseed, recognized globally for its versatility as both an oil and fiber crop, emerges as a key player in this trend. Its distinctive composition, including dietary fiber, essential fatty acids, protein, and phenolic compounds, positions flaxseed as a valuable addition to functional chocolates. Jaggery, derived from concentrated sugarcane juice, is a traditional sweetener with nutritional value, serving as a rich source of vitamins, essential minerals, and protein. The slow digestion of jaggery, coupled with its iron content, makes it a preferable alternative to refined sugar. The integration of flaxseed and jaggery into chocolate formulations not only adds nutritional value but also aligns with the growing consumer preference for healthier options (Rodriguez *et al*., 2010) [16].

Materials and Methods

Materials

Raw materials, including flaxseed, cocoa powder, cocoa butter, maltodextrin, vanilla essence, and jaggery were sourced from the local market in Parbhani. Chemicals and reagents were acquired from the laboratory at the Department of Food Science and Nutrition, College of Community Science, and the Department of Food Chemistry and Nutrition, College of Food Technology, VNMKV, Parbhani (MS).

Methods

Preparation of control chocolate: Developing control chocolate required the inclusion of particular ingredients. It started by melting 100 grams of milk compound chocolate in a double boiler, maintaining a temperature of 40-42 degrees Celsius. Then, 40 grams of cocoa butter was added to the melted chocolate, followed by the addition of 35 grams of sugar and 25 grams of cocoa powder to the mixture. The blend was continuously mixed for approximately 10-15 minutes at a temperature of 40-42 degrees Celsius. The chocolate mixture was poured into silicon molds, and it was allowed to set by keeping it at a temperature between 4 and 6 degrees Celsius for approximately 20 minutes.

100-gram Milk compound chocolate melted at 60 degree Celsius

↓

Addition of 40 gram of cocoa butter to the chocolate

↓

Addition of 25 gram of cocoa powder and 35 gram sugar to the mixture

↓

Continuous stirring at temperature 60-65 degree Celsius for 20 minutes

↓

Mixture poured into moulds and Set at temperature 4 to 6 degree Celsius for 20 min.

Fig 1: Flow sheet for preparation of control chocolate

Formulation, standardization and preparation of chocolate

The chocolate was prepared in Department of Food Science and Nutrition of the College of Community Science and Department of Food Chemistry and Nutrition, College of Food Technology, VNMKV, Parbhani (MS). The recipe was used for preparation of chocolate mentioned in Table 1 and Formulation and standardization of chocolate blended with flaxseed and jaggery in Table 2.

Table 1: Preparation of chocolate blended with different levels of Flaxseed

Ingredients	T_0 (Control)	T_1	T_2	T_3	T_4
Milk Compound(g)	100	100	100	100	100
Sugar(g)	35				
Jaggery(g)		35	35	35	35
Flaxseed Powder(g)		15	20	25	30
Cocoa Powder(g)	25	25	25	25	25
Cocoa Butter(g)	40	20	15	10	5
Maltodextrin(g)		4.5	4.5	4.5	4.5
Vanilla Essence(g)		0.5	0.5	0.5	0.5

Table 2: Standardized recipe for preparation of chocolate

Sr. No.	Ingredients	Quantity	Quantity in %
1.	Milk Compound	100 g	50 percent
2.	Jaggery	35 g	17.5 percent
3.	Flaxseed Powder	25 g	12.5 percent
4.	Cocoa Powder	25 g	12.5 percent
5.	Cocoa Butter	10 g	5 percent
6.	Maltodextrin	4.5 g	2.25 percent
7.	Vanilla Essence	0.5 g	0.25 percent

Flaxseeds were roasted at temperatures between 70 and 80 degrees Celsius until they became crunchy. They were then crushed and finely powdered. Granulated jaggery was similarly ground in a machine. For the chocolate base, 100 grams of milk compound were gently melted in a pan using the double boiler method, maintaining a temperature of 60–65 degrees Celsius. To this melted chocolate, 10 grams of cocoa butter and 25 grams of ground flaxseed were added. Simultaneously, 35 grams of powdered jaggery were gradually blended. Once the cocoa butter and jaggery powder were fully melted, 25 grams of cocoa powder and 4.5 grams of maltodextrin were added and continuously mixed until a dark color was achieved. Finally, 0.5 grams of vanilla essence were added. This mixing process continued for around 2025 minutes at a temperature of 60–65 degrees Celsius. The resulting chocolate blend was poured into silicone molds and chilled at 4 to 6 degrees Celsius for approximately 25 minutes until it set. This chocolate-making procedure was in close agreement with the procedure of Goyal A. and Dhingra H. (2021) [6].

Flaxseed roasted and finely powdered
↓
Granular jaggery was finely powdered
↓
100-gram Milk compound chocolate melted at 60 degree Celsius
↓
Addition of 10 gram of cocoa butter and 25 gram ground flaxseed to the chocolate
↓
Addition of 35 gram of jaggery powder to the chocolate
↓
Addition of 25 gram of cocoa powder and 4.5 gram of maltodextrin to the mixture
↓
Finally, add 0.5 gram of vanilla essence to the mixture
↓
Continuous stirring at temperature 60-65 degree Celsius for 25 minutes
↓
Mixture poured into moulds
↓
Set at temperature 4 to 6 degree Celsius for 25 minutes

Fig 2: Flow sheet for preparation of standardized chocolate

Organoleptic evaluation

A organoleptic evaluation of the products was carried out by a group of 30 panel members, who were academic staff from the College of Community Science in Parbhani. They utilized a 9-point Hedonic scale, which featured descriptive terms ranging from like extremely (rated as 9) to dislike extremely (rated as 1). The highest-rated sample, as determined by the sensory scorecard evaluation, was selected for further investigation.

Proximate composition of chocolate

Proximate composition such as fat, protein, moisture, crude fiber, dietary fiber determined by (AOAC, 2005) [3] method, carbohydrate by difference method.

Mineral analysis

The measurement of the mineral content in the chocolate, including calcium, phosphorus, magnesium, and other elements, was done in accordance with the standardised methods described in (Ranganna, 1985) [15].

Nutraceuticals analysis (omega-3 and omega 6 fatty acids)

The method for analyzing the omega-3 and omega-6 fatty acids was conducted using Gas Chromatography (GS) or Gas Chromatography-Mass Spectrometry (GS-MS) through the transesterification process (Handayani and Cornellia Budimarwan, 2006) [9].

Texture Analysis

The textural properties, such as hardness, springiness, cohesiveness and chewiness of chocolate were assessed using a TAXT2 *plus* texture analyzer.

Estimation of theoretical energy value of the product

Theoretical energy content of the prepared chocolate was determined using conversion factors for protein, fat, and carbohydrates, which are 4, 9, and 4 Kcal per gram, respectively, based on their proximate chemical composition.

Statistical analysis

Data collected underwent organization, tabulation, and statistical analysis, with sample analyses conducted in triplicate. Analysis of variance utilized the standard ANOVA procedure. The data for different treatments were recorded and statistically analyzed using CRD (complete randomized design), following Panse and Sukhatme's method (1967) [13] for significance determination. The ANOVA indicated significance at $P < 0.05$. Standard error (SE±) and critical difference (CD) at the 5 percent level were reported. Statistical distinction in nutrient content of chocolate, with and without flaxseed and granular jaggery powder, was assessed using a 't' test (Gupta, 2014) [7].

Result and Discussion

Organoleptic evaluation of chocolate

The sensory parameters considered are colour and appearance, flavour, texture, taste. The values are the mean score of mentioned sensorial parameters, as outline in Table 3 and Fig. 3.

Table 3: Organoleptic evaluation of chocolate prepared with and without a blend of granular jaggery and flaxseed powder

Variation	Mean values of organoleptic score				
	Colour & Appearance	Flavour	Texture	Taste	Overall Acceptability
C_0	8.9	8.6	8.6	8.7	8.7
T_1	8.7	8.4	8.2	8.5	8.4
T_2	8.6	8.2	8.2	8.3	8.3
T_3	8.8	8.5	8.3	8.8	8.6
T_4	8.1	7.9	7.7	7.9	7.9
S.E±	0.077	0.093	0.095	0.093	0.084
CD.@ percent5	0.215	0.259	0.266	0.260	0.234

The sensory score of colour from Table 3 represents that T_3 combination for overall acceptability got highest scores (8.8) as compared to other treatments. Lowest score found in T_1 (8.7), T_2 (8.6), and T_4 (8.1). The colour acceptance of different samples was occurring in different order due to percentage of flaxseed was increased. The colour of chocolate was darker because of the flaxseed contain pigment lignans and oils. The variation T_3 (8.8) was more accepted because of the similar colour to the control sample (8.9). The variation T_4 (8.1) was lower score than the other treatment because of percentage of cocoa powder and cocoa butter were lower than the percentage of flaxseed.

The sensory score of flavour from Table 3 represents that T_3 combination for overall acceptability got highest scores (8.5) as compared to other treatments. Lowest score found in T_1 (8.4), T_2 (8.2), and T_4 (7.9). The flavour acceptance of different samples was occurring in different order due to percentage of flaxseed was increased. The flavour of chocolate was distnct and appealing because of the flaxseed contain omega-3 fatty acids and lignans. Vanilla essence enhances the flavor profile with a hint of aroma. The variation T_4 (7.9) was lower score than the other treatment because of percentage of cocoa powder and cocoa butter were lower than the percentage of flaxseed.

Texture is the characteristics of touch and mouth feel. The results from Table 3 shows that the texture of chocolate T_3 secured maximum score (8.3) and lowest score found in T_4 (7.7) becomes percentage of cocoa powder and cocoa butter were lower than the percentage of flaxseed. T_3 secured highest score to texture because of flaxseed contained the soluble fiber which enhance and improve its texture to more acceptable level.

The sensory score of taste from Table 3 represents that T_3 combination for overall acceptability got highest scores (8.8) as compared to other treatments. Lowest score found in T_1 (8.5), T_2 (8.3), and T_4 (7.9). The taste acceptance of different samples was occurring in different order due to percentage of flaxseed was increased. The taste of chocolate was enhanced because of the flaxseed contain nutty taste. The variation T_4 (7.9) was lower score than the other treatment because of percentage of cocoa powder and cocoa butter were lower than the percentage of flaxseed.

Overall acceptability is the overall score of the sensory evaluation, it was observed that chocolate T_3 secured the maximum score (8.6) and it was cleared from the sensory evaluation that T_3 have maximum acceptability. Overall acceptability of T_4 was lower than other four samples (7.9). Statistical analysis reveals the significant deviation among the obtained results. All the samples was found to be statistically significant with each other.

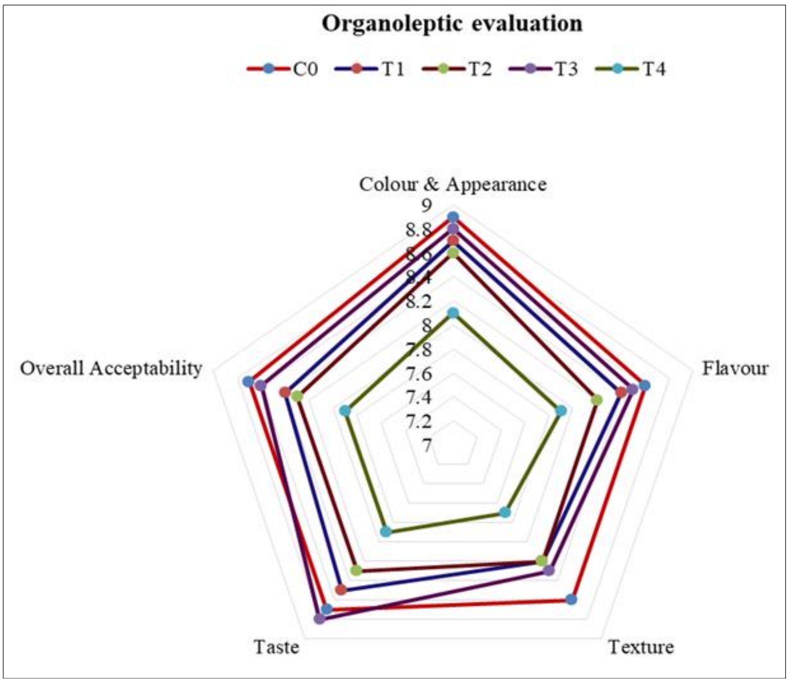

Fig 3: Organoleptic evaluation of chocolate prepared with and without a blend of granular jaggery and flaxseed powder

Proximate composition of chocolate

On the basis of results of organoleptic evaluation of tabulated in Table 3 sample T3 containing 12.5 percent flaxseed and 17.5 percent granular jaggery was selected for further analysis.

Table 4: Comparative study of the proximate composition of chocolate blended with and without granular jaggery and flaxseed powder

Sr. No	Nutrients	Nutrient Content		't' value	Increase / decrease in nutrient content
		Chocolate (Control) (Mean ± SD)	Chocolate (Accepted) (Mean ± SD)		
1	Moisture (%)	2.87±0.02	5.45±0.54	7.93*	+2.58
2	Ash (%)	1.49±0.01	2.91±0.07	40.34*	+1.42
3	Protein (%)	4.99±0.10	8.03±0.13	131.85**	+3.04
4	Carbohydrate (%)	48.26±0.43	48.92±0.24	191.98^{NS}	+0.66
5	Fibre (%)	4.77±0.02	7.34±0.15	32.56*	+2.57
6	Fat (%)	37.62±0.76	27.35±0.24	64.99*	-10.27

NS: Non significant *Significant at 5 percent ** Significant at 1 percent

The moisture content of the control and accepted chocolates was estimated to be 2.87 percent and 5.45 percent respectively. The tabulated data indicates that as flaxseed and granular jaggery content increased, moisture content increased. The protein, carbohydrates, fat, fiber and ash of control chocolate were 4.99 percent, 48.26 percent, 37.62 percent, 4.77 percent and 1.49 percent respectively. The corresponding values of accepted chocolate for above tabulated nutrients were 8.03 percent, 48.92 percent, 27.35 percent, 7.34 percent, and 2.91 percent. From the results it was conclude that accepted chocolate contained protein, fiber and ash in increased amount because of 100 grams of flaxseed contained 19.96 percent of protein, flaxseed and jaggery contained 5.9 and 0.93 percent of fiber per 100 grams respectively. These differences were statistically significant. The fat content of the accepted chocolate decreased, attributed to lower amounts of cocoa butter and addition of 2.25 percent of maltodextrin. The results inferred that the incorporation of flaxseed and granular jaggery in chocolate was helpful in increasing the nutrient content.

Minerals composition of chocolate

Table 5 depicts the mineral composition, including calcium, phosphorus, iron, copper, zinc, and magnesium, of both the control and accepted chocolate.

Table 5: Comparative study of minerals composition of chocolate blended with and without granular jaggery and flaxseed powder

Sr. No	Minerals (mg/100g)	Nutrient Content		't' value	Increase / decrease in nutrient content
		Chocolate (Control) (Mean ± SD)	Chocolate (Accepted) (Mean ± SD)		
1	Calcium (Ca)	104.2±0.27	149.41±0.05	293.83**	+45.21
2	Phosphorus (P)	90.73±0.07	153.76±0.04	3369.23**	+63.03
3	Iron (Fe)	3.06±0.03	5.10±0.01	153.24**	+2.04
4	Copper (Cu)	1.55±0.05	1.74±0.02	8.53**	+0.19
5	Zinc (Zn)	0.94±0.02	1.53±0.04	178.00**	+0.59
6	Magnesium (Mg)	0.69±0.03	52.65±0.06	52.81*	+51.96

NS: Non significant *Significant at 5 percent ** Significant at 1 percent

The tabulated data illustrate the mineral composition of the control sample and accepted sample of chocolate. The calcium, phosphorus, iron, copper, zinc and magnesium of control chocolate were 104.2 mg/100 g, 90.73 mg/100 g, 3.06 mg/100 g, 1.55 mg/100 g, 0.94 mg/100 g and 0.69 mg/100 g respectively. The corresponding values of accepted chocolate for above tabulated nutrients were 149.41 mg/100 g, 153.76 mg/100 g, 5.10 mg/100 g, 1.74 mg/100 g, 1.53 mg/100 g and 52.65 mg/100 g. The phosphorus content of chocolate was found to be highest (153.76 mg), attributed to flaxseed containing the highest amount of phosphorus among other minerals. The study showed that chocolate was good sources of calcium, iron, copper, zinc and magnesium. The incorporation of flaxseed and jaggery in chocolate was found to be significantly increased of total minerals content.

Nutraceuticals analysis (omega-3 and omega 6 fatty acids)

The data regarding the total content of omega-3 and omega 6 fatty acids in the control and the accepted variation of chocolate was shown in Table 6.

Table 6: Comparative study of essential fatty acids of chocolate blended with and without granular jaggery and flaxseed powder

Sr. No.	Essential fatty acids (mg/100g)	Nutrient Content		't' value	Increase / decrease in nutrient content
		Chocolate (Control) (Mean ± SD)	Chocolate (Accepted) (Mean ± SD)		
1	Omega-3 fatty acid	93.45±0.02	1580.28±19.6	156.73**	+1486.83
2	Omega-6 fatty acid	296.66±0.05	373.26±14.3	21.18*	+76.6

NS: Non significant *Significant at 5 percent ** Significant at 1 percent

The omega-3 fatty and omega-6 fatty acids content of control chocolate was found 93.45 mg/100 g and 296.66 respectively to be significantly lower than of the accepted chocolate was 1580.28 mg /100 g and 373.26 mg/100 g. This increase in omega-3 and omega-6 fatty acids content due to flaxseed oil content 57 percent α- Linolenic acid (omega-3 fatty acids) and 16 percent Linolenic acid (omega-6 fatty acid) Unsaturated fatty acid present in cocoa butter are oleic acid (26.3-35%), palmitoleic acid (0-4%), linoleic acid (1.7-3%) and α- linolenic (0-1%) acid reported by Gunstone, 2011 [8].

Texture Analysis

Texture profile analysis was performed on control and accepted (T3) chocolate samples. The parameters used for texture profile analysis were hardness, springiness, cohesiveness and chewiness. The result of textural profile analysis has been illustrated in Table 7.

Table 7: Comparative studies of textural parameters of control and accepted chocolates

Sr. No	Textural Parameters	Control (Mean ± SD)	Accepted (Mean ± SD)	't' value	Increase / decrease observed
1	Hardness (kg)	5.03±0.004	12.776±0.006	2581.00**	+7.746
2	Springiness (mm)	0.826±0.001	0.622±0.002	203.00**	-0.204
3	Cohesiveness	0.596±0.002	0.626±0.003	90.99**	+0.03
4	Chewiness (g-mm)	2.600±0.003	4.736±0.001	10.19^{NS}	+2.136

NS: Non significant *Significant at 5 percent ** Significant at 1 percent

The control chocolate exhibited less hardness (5.03 kg) compared to the accepted chocolate, prepared with 12.5% flaxseed powder and 17.5% granular jaggery powder (12.776 kg). There was a statistically significant increase of 7.746 units in hardness for the accepted variation. The control chocolate was springier (0.826 mm) than the accepted one (0.622 mm), with a non-significant decrease of 0.204 mm in springiness for the accepted chocolate. In terms of cohesiveness, the accepted chocolate (0.626 units) showed a statistically significant increase of 0.03 units compared to the control chocolate (0.596 units). Chewiness of the control (2.600 g-mm) was significantly lower than that of the accepted chocolate (4.736 g-mm), indicating a substantial increase of 2.136 units in chewiness for the accepted variation. The incorporation of flaxseed and jaggery powder influences texture, with flaxseed contributing to hardness and jaggery enhancing cohesiveness and chewiness in the accepted chocolate.

Estimation of theoretical energy value of the product

The theoretical energy value of 100 g control chocolate and accepted (T_3) depicts in Table 8.

Table 8: Theoretical energy value of control and accepted chocolate

Sample	Carbohydrate (Kcal)	Protein (Kcal)	Fat (Kcal)	Total energy (Kcal/100 g)
Control	193.04	19.96	338.58	551.58
Accepted (T_3)	195.68	32.12	246.15	473.95

Table 8 revealed that total energy value of control chocolate sample is 551.58 Kcal while total energy value of accepted chocolate sample is 473.95 Kcal. Results showed that the total energy value of accepted chocolate T_3 was found to be lower than the control chocolate. This is due to high concentration of fat (37.62) in control sample.

Conclusion

In conclusion, the organoleptic evaluation of chocolates reveals that the combination T_3, containing 12.5% flaxseed and 17.5% granular jaggery, consistently scored highest in color, flavor, texture, taste, and overall acceptability. The darker color of T_3 was well-received, attributed to the presence of flaxseed pigments. Flaxseed contained omega-3 fatty acids contributed to a distinct and appealing flavor. Accepted chocolate (T_3) texture was enhanced by soluble fiber in flaxseed. The taste was enriched by the nutty flavor of flaxseed. Proximate composition analysis showed accepted chocolate (T_3) had increased protein, fiber, and ash, while fat decreased compared to the control chocolate. Minerals composition revealed significant increases in calcium, phosphorus, iron, copper, zinc, and magnesium in accepted chocolate (T_3). Nutraceutical analysis indicated significant boosts in omega-3 and omega-6 fatty acids in accepted chocolate (T_3). Texture analysis demonstrated accepted chocolate (T_3) increased hardness, cohesiveness, and chewiness. The accepted chocolate had a lower theoretical energy value due to reduced fat content compared to the control. Overall, the incorporation of flaxseed and jaggery positively influenced sensory attributes, nutritional content, and texture of the chocolate.

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