



PREPARATION & NUTRITIONAL EVALUATION OF VALUE-ADDED PRODUCT WITH JAGGERY

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ABSTRACT

This research article explores the use of jaggery in value added products, focusing on their preparation and nutritional benefits. Jaggery, a traditional sweetener, has gained attention for its potential health advantages. The article discusses various methods of incorporating jaggery into different foods to improve their sensory and nutritional qualities. It critically analyses the nutritional content, including vitamins, minerals and antioxidants, highlighting the potential health benefits of these products. The research also addresses challenges in production, shelf life and consumer acceptance. By shedding light on the preparation & nutritional aspects, this article contributes to our understanding of creating innovative and nutritious foods using jaggery.

Jaggery enriched bar was produced and goal was to conduct a sensory evaluation to assess the taste, texture & overall acceptability of the bar, comparing them to traditional versions and identifying any sensory improvements. Plan to carry out consumer perception surveys to gain insights into consumer awareness, preferences, and attitudes towards both jaggery and the enhanced products. This research aims to provide valuable insights for marketing and future product refinement.

Results showed that jaggery bars made with cane sugar jaggery and date palm jaggery are nutritionally superior, boasting higher protein and fiber content. Additionally, these bars excel in micronutrients, with date palm jaggery-based bars containing more iron, phosphorus and calcium, while sugarcane jaggery-based bars have greater amounts of magnesium and potassium.

Keywords: Jaggery, Antioxidants, Micronutrients.

1. Introduction

Jaggery, also known as “Gur”, is a type of non-centrifugal sugar (NCS) that is widely used in many Asian, African, and South American countries, including India and Colombia. Unlike refined white sugar, which mainly consists of only sucrose, jaggery contains minerals, vitamins, glucose, fructose (invert sugars) in addition to sucrose [Rao et al., 2022]. Jaggery is rich in various minerals such as calcium, phosphorus, magnesium, potassium, zinc, iron and copper. These minerals play key roles in maintaining overall health and well-being. Additionally, jaggery contains vitamins, including folic acid and B-complex vitamins, which are important for various protective functions of the body. Jaggery is consumed also due to its high energy content due to the presence of high amounts of carbohydrate. It is often used in Ayurvedic medicine for its medicinal properties.

Jaggery of high quality is golden yellow in colour, hard in texture, crystalline in structure, sweet in taste and low in moisture. A good quality jaggery contains over 70% sucrose, below 10% of glucose and fructose, less than 5% minerals and under 3% moisture. [Hirpara et al., 2020] The quality jaggery is influenced by the variety of cane used, quantity of fertilizers used, quality of irrigation water and method of processing adopted.

Regular and high consumption of white sugar can result in many health-related problems including dental, stomach problems diabetes, obesity, etc. However, jaggery is supposed to be a source of more wholesome and healthy sugar due to its inherent richness in minerals, antioxidants, vitamins & protein. It is often considered a healthier alternative to white sugar due to its improved nutritional profile as mentioned above. Still, the wider societal acceptance and consumption of jaggery products are limited because of poor hygiene in manufacturing, the use of excessive chemicals to get attractive colours, and poor storability of the produce. Jaggery manufacturing is an ancient practice & a significant cottage industry in rural areas of our country. It possesses higher medicinal & nutritional values compared to other sweeteners. It is an easily accessible to rural communities and highly recommended by health experts. Jaggery finds numerous applications in a variety of foods, and its use in households makes it a preferable choice over regular sugar. Additionally, jaggery is associated with various health benefits, making it a superior alternative to sugar.

Jaggery, also referred to as “medicinal sugars”, is widely recognized for its use in pharmaceutical formulations and daily consumption [2020]. It has been suggested that consuming jaggery may be associated with an increased human lifespan, Jaggery is abundant in minerals and contains a significant amount of phenol. Various authors in literature have highlighted multifaceted health benefits of jaggery including improved digestion, liver cleansing, relief from constipation, increased energy levels, blood purification, anti-toxic and anti-carcinogenic properties, stress relief, treatment of bronchial or lung infections and premenstrual syndrome (PMS), and antioxidant activity.

It is an important to note that while jaggery does offer certain nutritional benefits, it is still a form of sugar and should be consumed in moderation [Rad et al., 2023]. Excessive consumption of any type of sugar can

have negative effects on health, such as weight gain and increased risk of chronic diseases like diabetes and heart diseases.

Oats are highly nutritious grain that offer numerous health benefits. Their importance stems from their rich nutritional profile and various positive effects on overall health. Oats are a good source of essential nutrients, including complex carbohydrates, protein, protein, vitamins and minerals (such as iron, magnesium & zinc). Regular consumption of oats has been associated with a reduced risk of heart disease due to its high fibre content. [Ahmad et al., 2014] The fibre content in oats also aids in promoting healthy digestion and preventing constipation. It supports the growth of beneficial gut bacteria, contributing to a healthy gut microbiome. Oats contain various antioxidants such as, avenanthramides, which have anti-inflammatory properties and can protect cells from oxidative stress [Peterson et al., 2001].

Fruit consumption is always promoted in today's scenario where people are mostly concentrating on fast food consumption due to its luscious taste. It is advised that at least one fruit should be included in everyone's food plate due to its high antioxidant and micronutrient content but rarely people go by the advice. Mango, hailed as the 'king of fruits', holds remarkable importance due to its delectable taste, immense nutritional value, and versatile culinary applications. Due to the presence of vitamins like A & C as well as essential minerals like potassium consumption of mango is said to improve the immune system, improve the function of eye with special reference to vision. Vitamin A and C present in mango which are natural antioxidants makes mango an oxidative stress reducer thereby decreasing the risk of chronic disease [Bezu et al., 2014]. Pomegranate, often hailed as a "superfood", holds significant importance due to its remarkable health benefits and nutritional value. Packed with antioxidants, pomegranate seeds and juice offer potent protection against oxidative stress, which can help reduce the risk of chronic diseases such as heart disease, cancer, and diabetes. The fruit's rich antioxidant content, particularly punicalagins and anthocyanins, contribute to its anti-inflammatory properties, supporting overall immune function & promoting a healthy inflammatory response in the body [Rowayshed et al., 2013] [Negi et al., 2003]. Pomegranate is a versatile fruit that can be used in a multitude of ways, from enjoying the seeds as a snack or adding them to salads and desserts to using the juice in marinades, dressings, and smoothies. Dates, the sweet and delicious fruit of the date palm tree, hold significant importance in both nutrition and culture. Dates are a great natural source of energy due to their high carbohydrate content, which provides a quick boost in vitality, making them an ideal snack for athletes and those needing a quick pick me up [Ali et al., 2012]. The presence of vitamins and mineral, including potassium, magnesium and iron, contributes to better heart health, muscle function and the prevention of anaemia. Dates also contain antioxidants such as flavonoids and carotenoids, which help free radicals and reduce oxidative stress in the body, thereby supporting well-being and potentially reducing the risk of chronic diseases [Al-Farsi et al., 2005] [Allaith et al., 2005].

Beetroot, with its vibrant hue and earthy flavour, boasts remarkable importance as a nutrient-dense vegetable which cater many health benefits. Packed with essential vitamins and mineral like folate, potassium, and vitamin C, beetroot supports a healthy immune system, aids in blood pressure regulation and promotes

cardiovascular health. Its natural nitrates have been shown to enhance athletic performance and increases blood flow, leading to improved endurance during physical activities. Its multi-faceted health benefits and culinary versatility make beetroot a valuable & enjoyable addition to a balanced and nutritious diet [Clifford et al., 2015].

Groundnuts, also known as peanuts, hold significant importance due to their nutritional value, culinary versatility, and economic impact [Rami et al., 2013]. These legumes are an excellent source of protein, providing a vital dietary component for individuals, especially vegetarians and vegans, who may struggle to meet their protein needs from other sources. Groundnuts are also rich in healthy fats, particularly monounsaturated fats, which are beneficial for heart health and can help lower bad cholesterol levels. Groundnuts can be consumed in various forms, including raw, roasted, or ground into peanut butter, making them a convenient and delicious snack option. Their ability to thrive in various climates and soil conditions makes groundnuts a valuable crop for sustainable agricultures, helping communities combat food insecurity and poverty while promoting agricultural diversity [He G et al., 2005].

Consumption of seeds like chia seeds, flaxseed, pumpkin seeds have gained immense importance due to their nutritional implications. Chia seeds have gained significant importance and popularity in the recent years due to their exceptional nutritional profile and numerous health benefits. These seeds are a powerhouse of essential nutrients, including omega-3 fatty acids, protein, fiber, antioxidants, vitamins and minerals. Their high omega-3 content makes them particularly beneficial for heart health by reducing inflammation, improving cholesterol level & supporting cardiovascular function. [Marcinek et al., 2017] [Reyes-Caudillo et al., 2008] This unique property promotes hydration and helps to slow down digestion, leading to more sustained release of energy and increased feeling of fullness, making them a beneficial tool for weight management. Moreover, the soluble fiber in chia seeds aids in regulating blood sugar levels, making them especially beneficial for individuals with diabetes or those aiming to maintain stable energy levels throughout the day. [Nieman et al., 2009] Flaxseeds, derived from the flax plant (*Linum usitatissimum*), have garnered significant attention in the realm of nutrition and wellness for their exceptional health benefits. One of the most prominent features of flaxseeds is their high concentration of alpha-linolenic acid (ALA), a type of omega-3 fatty acid. [Soni et al., 2016] ALA is essential for maintaining cardiovascular health, reducing inflammation, and supporting brain function. Flaxseeds contain lignans, which are antioxidant compounds that help protect the body's cells from damage caused by free radical, potentially reducing the risk of chronic diseases like cancer and promoting overall longevity. [de et al., 2001] [Block et al., 1992] [Flower et al., 2013] These seeds are rich in both soluble and insoluble Fiber, aiding in digestive health and promoting regular bowel movements. Soluble Fiber helps to lower cholesterol levels by binding to bile acids in the intestine and facilitating their elimination from the body. Pumpkin seeds, also known as pepitas, are a nutritional power house and have garnered attention for their impressive health benefits. One of their standout features is their high content of magnesium, which plays a crucial role in maintaining healthy blood pressure levels, supporting muscle and nerve function & promoting bone health. Pumpkin seeds are abundant in zinc, an essential mineral that supports in zinc, an essential mineral that supports the immune

system, aids in wound healing, and contributes to healthy skin. [Syed et al., 2019] Their combination of essential nutrients makes pumpkin seeds a valuable superfood that contributes to overall well-being and disease prevention.

Although in this testing time of pandemic jaggery products are gaining momentum because of health awareness and demerits of refined sugar consumption; however, there is still enormous scope to [D. Dutta et al., 2015] increase the consumption of this nutritious healthy sweetener(jaggery) by introducing & making different value-added products.

The aim of the study is to investigate and develop innovative value-added food products incorporating jaggery, in order to expand its culinary applications beyond traditional uses and to conduct comprehensive nutritional analysis of the newly developed product, including assessments of macronutrients, micronutrients, and phytochemicals to determine their potential health benefits.

2. Materials & Methods

2.1 Materials

Oats, jaggery date palm, jaggery liquid, sugar, beetroot, pumpkin seeds, flaxseeds, chia seeds, pomegranate, dates, mango, groundnut were purchased from the local market.

2.2. Preparation of protein bar with jaggery (date palm & cane sugar) & sugar:

First, the oven will be pre heated to 350°F. A baking dish will be lined with parchment paper it with cooking spray. In a large mixing bowl, oats, jaggery (dates palm [TJD] & cane sugar [TJS]) & sugar [TS], pumpkin seeds, chia seeds, flaxseeds, pomegranate, dried mango, beetroot & groundnut will be combined. Mixing well to ensure the ingredients are evenly distributed. In a separated small bowl, mashing the dates with a fork until they form a sticky paste. Then a teaspoon of water will be added if needed to help with the mashing process. Addition of the mashed dates to the large mixing bowl with the other ingredients. Hands or a spoon will be used to mix everything thoroughly until the mixture becomes sticky and holds together when pressed. Transferring the mixture to the prepared baking dish. Using spatula to press it down firmly. The baking dish will be placed in the preheated oven and bake for about 15-20 minutes or until the edges turn golden brown. After that the item will be removed from the oven and the protein bar slab from the dish and cut it into individual bars.

Table 1: Composition of protein bar with jaggery

Sl No	Ingredients	Amount (g/100g)
1.	Oats	16.68±0.22

2.	Dates	18.31±0.20
3.	Pumpkin seeds	0.82±0.10
4.	Ground Nut	8.26±0.02
5.	Chia seeds	3.56±0.03
6.	Flax Seeds	3.62±0.02
7.	Jaggery	10.04±0.18
8.	Beetroot	2.92±0.20
9.	Pomegranate	3.13±0.02
10.	Mango	33.64±0.23



Fig 1: Protein bar with jaggery date palm (TJD), jaggery sugar cane (TJS) & sugar (TS)

2.3. Analytical Procedures:

The proximate analysis of jaggery such as moisture content, ash content, fat content, proteins content, total carbohydrates, reducing and non-reducing sugar & crude fibre was performed by the method described below:

2.3.1. Determination of fat content method

In 0.5 gm of the sample and 5 ml Hexane was mixed and Shaked. Then the solution was poured into a beaker and Shaked for 5-10 mins and later filtered. The solution was again heated until yellow precipitation formed. After that 5 ml chloroform is added [Sehgal et al., 2021].

2.3.2. Determination of moisture content by using hot air oven

The sample was weighed in a clean & tarred moisture dish, initially 5 gm. The dish was then placed in the hot air oven, which was maintained at 110°C with the lid open, for about 1 hr. After that, the dish was removed from the oven & the lid was closed, and it was cooled in a desiccator. The cooled dish was then rejected. Secondly, the dish was placed in the hot air oven maintained at 110°C for about 30 mins. The dish was removed from the hot air oven and cooled in a desiccator. The cooled dish was then weighed again. Thirdly, the dish was placed in the hot air oven maintained at 110°C for about 30 mins, and then it was removed from the hot air oven. The dish was cooled in a desiccator and weighed. Finally, the moisture content was calculated using the formula: $W2_W3/W2_W1 \times 100$ [2021].

2.3.3. Determination of protein content method

Firstly, 3 ml biuret reagent was mixed with a 0.2, 0.5- & 1-ml portion of the protein sample. Then the reaction mixture was allowed to stand at room temperature for 15-30 mins, the absorbance is read at 540 nm against a reagent blank. After that, filtration before reading absorbance was required the reaction mixture was not clear [2021].

2.3.4. Determination of Total carbohydrates by anthrone method

Firstly, 0.1 gm of the sample was mixed with 5 ml of HCL and boiled for 1 hr and then cooled to room temperature. Then the mixture was neutralized with sodium carbonate and the volume was made up to 100 ml. The standards were prepared by taking 0.25 µl & 0.50 µl of the working standards and adding distilled water to make up the volume. Then, 4 ml of anthrone reagent was added and the green colour formed was observed. Finally, the solution was measured at od 630 nm [2021].

2.3.5. Determination of ash content

At first, 2 gm of the sample was weighed in a tarred crucible. The crucible was placed in a muffle furnace at 600°C for 6 hr. Then the muffle furnace was turned off and the crucible was transferred to a desiccator for cooling. Finally, the total ash was weighed and calculated [2021].

2.3.6. Determination of crude fiber

Firstly, 2 gm of the sample was weighed and mixed with 200 ml of sulfuric acid, boiled for 30 mins, and then cooled to room temperature. The mixture was filtered through muslin cloth and washed with boiling water. Then, 200 ml of sodium hydroxide was added, and the mixture was boiled for 30 mins. After cooling to room temperature, the mixture was again filtered through muslin. The sample was transferred to a silica crucible and placed in a muffle furnace for 1 hr at 600°C. Then, the crucible was cooled in a desiccator and weighed, and the value was calculated [2021].

2.3.7. Determination of reducing and non-reducing sugar method

Firstly, 5 gm of the sample was taken into a conical flask and 46 ml of acetate buffer, 2 ml of sulfuric acid and 2 ml of sodium tungstate solution were added. Then the content was filtered using two stoppered test tubes labelled A & C. Next 10 ml of potassium ferricyanide was added, and the mixture was boiled in a

water bath for 20 mins. After cooling to room temperature, the conical flask containing 25 ml of acetic acid solution was transferred. Then 1 ml of potassium iodide and 1 ml of starch indicator was added. Finally, the solution was titrated until a white colour formed [2021].

2.3.8. Determination of mineral content

Mineral content of the samples was estimated using Inductively coupled plasma mass spectrometry (ICPMS).

2.3.9. Determination of Fatty acid composition

Fatty acid composition of the protein bars was analyzed by GC. Fatty acid ethyl esters (FAME) were prepared by the method described by Metcalfe and the compositions were determined by GC analysis. The GC (make: Agilent, model: 6890 N) instrument used was equipped with an FID detector and capillary DB Wax column (30mL, 0.32mm I.D, 0.25µm FT). N₂, H₂ and airflow rate were maintained at 1ml/min, 30ml/min, and 300ml/min, respectively. Inlet & detector temperature was kept at 250°C, and the oven temperature was programmed as 150-190-230°C with an increased rate of 15°C/min and 5 min hold up to 150°C and 4°C/min with 10 min hold up to 230°C. The percentage proportions of fatty acids were calculated.

2.3.10. Determination of polyphenol method

0.5 gm of sample is taken and mixed with 5 ml of methanol. Then the solution is poured into a beaker and stirred for 5-10 mins and then filtered. Then on 600µl of the solution and 600µl of the aluminium chloride Eppendorf was mixed. Then the solution was incubated for 1 hr and later od value was measured against 420 nm [2021]

2.3.11. Determination of flavonoid method

In the sample of 0.1 gm & 3ml dimethyl sulfoxide (DMSO) was added and then stirred 5-10 mins. Then the solution was filtered. From this 500µl and 1000µl sample was taken. Then 1 ml Folin reagent was added into it and then od value measured in 517 nm [2021].

2.3.12. Determination of reducing activity method

(0.25 ml) 1% of potassium ferrocyanide is mixed with 1% extract (0.1 ml). The mixture is then was heated for 20 minutes at 50°C and then it is cooled. 10% TCA from 2.5 ml TCA solution is mixed with the solution and it is centrifuged for 5 minutes. After centrifugation 0.25 ml of the supernatant is mixed with 2.5 ml of 0.1% FeCl₃. The solution is kept for a 10 minutes stand and then absorbance is measured under 700 nm [2021].

2.3.13. Antibacterial property

The antibacterial effectiveness was assessed using the agar well diffusion method. In this experiment, both Gram-positive (*Staphylococcus aureus*) and Gram-negative bacteria (*E. coli*) were chosen. Culture was mixed with molten cooled sterile Mueller-Hinton agar and was poured into 2 petri-plates. 60µl of jaggery sample was added to each well. The plates were then incubated for 24 hours at 37°C and the results were

assessed by measuring the size of the incubation zone surrounding the wells on the agar plates [Harish et al., 2011].

2.3.14. Organoleptic evaluation

Sensory evaluation of protein bar with jaggery date palm ((TJD), cane sugar jaggery (TJS) and sugar (TS) was carried out by 20 normal people [Mahalaxmi et al., 2019].

2.3.15. Statistical analysis:

All the values were repeated trice and the mean obtained was given

3. Results & Discussions

3.1. Changes in Proximate analysis:

Proximate analysis for control protein bar with sugar, Protein bar with cane sugar jaggery and protein bar with jaggery date palm samples are portrayed in the Table 2. For control protein bar with sugar sample, moisture, fat, ash & crude fiber content was found to be: 5.25%, 16.89%, 0.23% and 3.84%; whereas for protein bar with cane sugar jaggery sample it was 5.50%, 15.58%, 0.99% & 4.71% and protein respectively. And protein bar with jaggery date palm sample, moisture, fat ash & crude fiber content was 5.80%, 15.54%, 1.21% & 5.34% respectively.

Moreover, the protein and carbohydrate content were found to be 15.15% & 58.64% for control protein bar with sugar, 18.19% & 55.03% for protein bar with cane sugar jaggery and 19.65% & 52.46% for protein bar with jaggery date palm, respectively.

Table 2: Proximate composition of Protein Bars

PARAMETERS	CONTROL PROTEIN BAR WITH SUGAR	PROTEIN BAR WITH CANE SUGAR JAGGERY	PROTEIN BAR WITH JAGGERY DATE PALM
Fat content (%)	16.89±0.11	15.58±0.12	15.54±0.06
Moisture content (%)	5.25±0.20	5.50±0.02	5.80±0.09
Protein content (%)	15.15±0.18	18.19±0.11	19.65±0.11
Carbohydrate content (%)	58.64±0.71	55.03±0.90	52.46±0.03
Ash content (%)	0.23±0.01	0.99±0.01	1.21±0.01
Crude fiber content (%)	3.84±0.09	4.71±0.11	5.34±0.90

Values are Mean±SD (n=3)

Table 3: Reducing & Non-Reducing sugar

PARAMETERS	CONTROL PROTEIN BAR WITH SUGAR	PROTEIN BAR WITH CANE SUGAR JAGGERY	PROTEIN BAR WITH JAGGERY DATE PALM
Reducing sugar (%)	2.30±0.06	9.88±0.09	12.30±0.10
Non-Reducing Sugar (%)	97.70±0.12	90.12±0.17	87.70±0.26

Values are Mean±SD (n=3)

5.2. Changes in Mineral content:

Table 4 showed the mineral content of control protein bar with sugar (TS), Protein bar with cane sugar jaggery (TJS) & Protein bar with date palm jaggery (TJD). Potassium was found to be the mineral with the highest percentage composition in Protein bar with cane sugar jaggery (TJS) samples, while Copper was the least for the sample.

Table 4: Mineral Content of Protein Bars

Name of Minerals	CONTROL PROTEIN BAR WITH SUGAR	PROTEIN BAR WITH CANE SUGAR JAGGERY	PROTEIN BAR WITH JAGGERY DATE PALM
Iron (mg/g)	4.58±0.11	4.97±0.07	13.80±0.70
Phosphorus (mg/g)	291.45±0.29	291.10±0.99	294.11±0.19
Magnesium (mg/g)	70.67±0.89	93.01±1.20	67.47±1.99
Calcium (mg/g)	116.36±0.89	125.08±0.99	168.19±1.22
Potassium (mg/g)	449.27±0.18	464.63±1.80	446.91±0.88
Zinc (mg/g)	1.94±0.01	1.91±0.02	1.90±0.02
Copper (mg/g)	0.36±0.01	0.37±0.01	0.37±0.01

5.3. Fatty acid composition:

Table 5 showed the fatty acid profile of lipid content of Protein bar with cane sugar jaggery (TJS). Oleic acid (C18:1) was found to be the fatty acid with the highest percentage composition in Protein bar with cane sugar jaggery (TJS) samples, while Myristic acid was the least for the sample.

Table 5: Fatty acid composition of Protein bar with sugar cane jaggery

SL No	Name of fatty acid	Amount (%w/w)
1	Myristic Acid (C14:0)	0.24
2	Palmitic Acid (C16:0)	14.09
3	Stearic Acid (C18:0)	5.30
4	Oleic Acid (C18:1)	33.74
5	Linoleic Acid (C18:2)	33.20
6	Arachidic acid (C20:0)	0.90
7	Linolenic Acid (C18:3)	10.15
8	Behenic Acid (C22:0)	1.50
9	Lignoceric Acid (C24:0)	0.88

5.4. Polyphenol content:

From fig 2 it was observed that the total phenolic content of all the three samples control protein bar with sugar (TS), protein bar with cane sugar jaggery (TJS) and protein bar with jaggery date palm sample (TJD); were as follow :0.99 mg GAE/g, 3.89mg GAE/g, 4.56 mg GAE/g because jaggery polyphenol is high other ingredients of protein bar.

5.5. Flavonoid content:

From Fig. 3 it was observed that the flavonoid content of all the three samples control protein bar with sugar (TS), protein bar with cane sugar jaggery (TJS) and protein bar with jaggery date palm (TJD) sample; were as follow: 2.02 mg QUE/g, 2.92 mg QUE/g & 3.22 mg QUE/g because chia seeds flavonoid value is high other ingredients of protein bars.

Table 6: Polyphenol Content and Flavonoid content

PARAMETERS	CONTROL PROTEIN BAR WITH SUGAR	PROTEIN BAR WITH CANE SUGAR JAGGERY	PROTEIN BAR WITH JAGGERY DATE PALM
Polyphenol content (mg GAE/g)	0.99	3.89	4.56
Flavonoid content (mg QUE/100g)	2.02	2.92	3.22

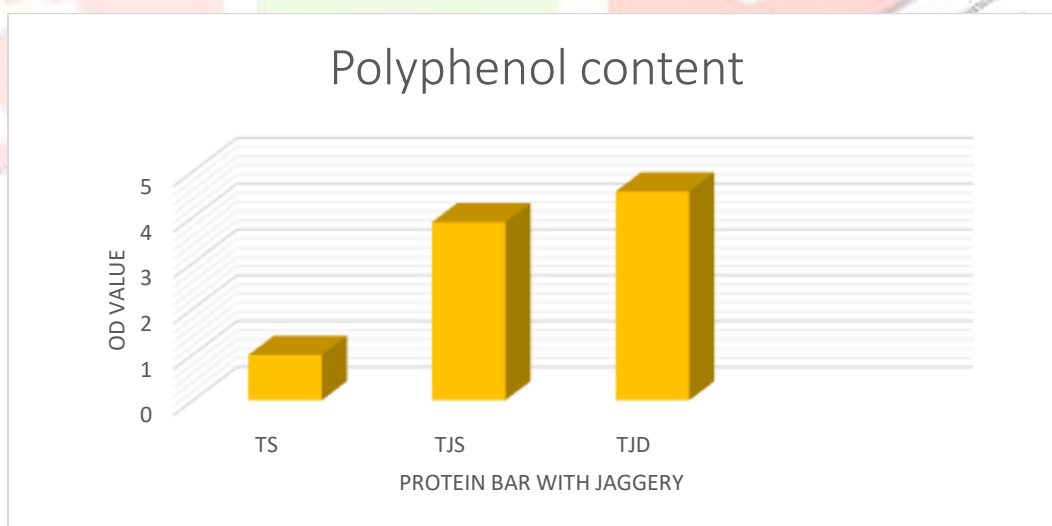


Fig 2: protein bar jaggery of polyphenol content

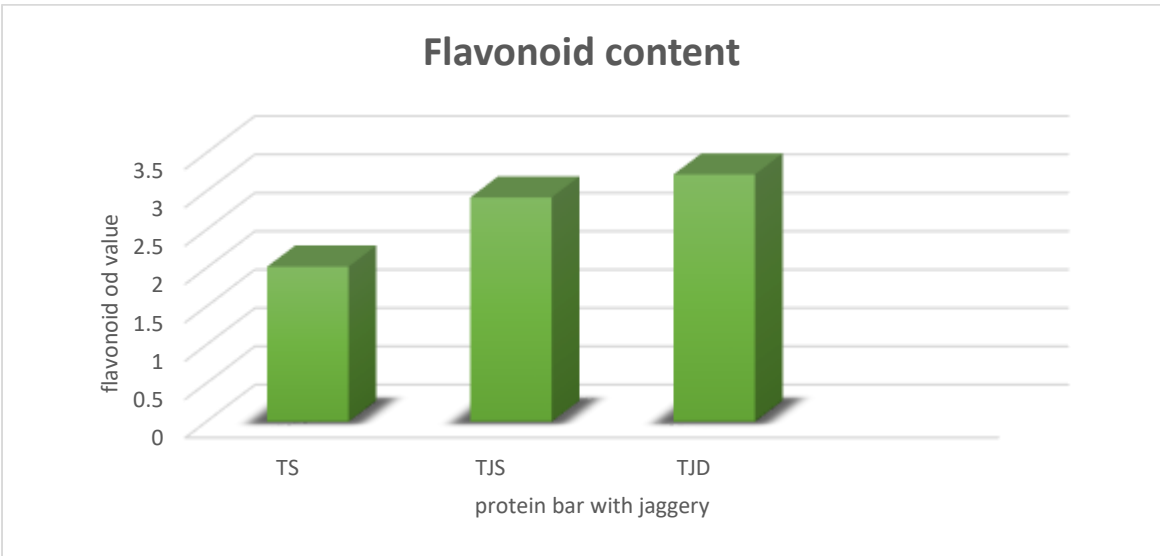


Fig 3: protein bar jaggery of flavonoid content

5.6. Antioxidant property:

The antioxidant properties of the Control protein bar with sugar (TS), protein bar with sugar cane jaggery (TJS) & protein bar with jaggery date palm (TJD) are illustrated in Figure 4. 0.410 µg/ml, 0.749 µg/ml & 0.745 µg/ml because jaggery increased antioxidant activity as revealed by DPPH radical scavenging ability & reducing power potential.

Table 7: Antioxidant Property

PARAMETERS	CONTROL PROTEIN BAR WITH SUGAR (TS)	PROTEIN BAR WITH CANE SUGAR JAGGERY (TJS)	PROTEIN BAR WITH JAGGERY DATE PALM (TJD)
Reducing activity	0.410	0.749	0.745

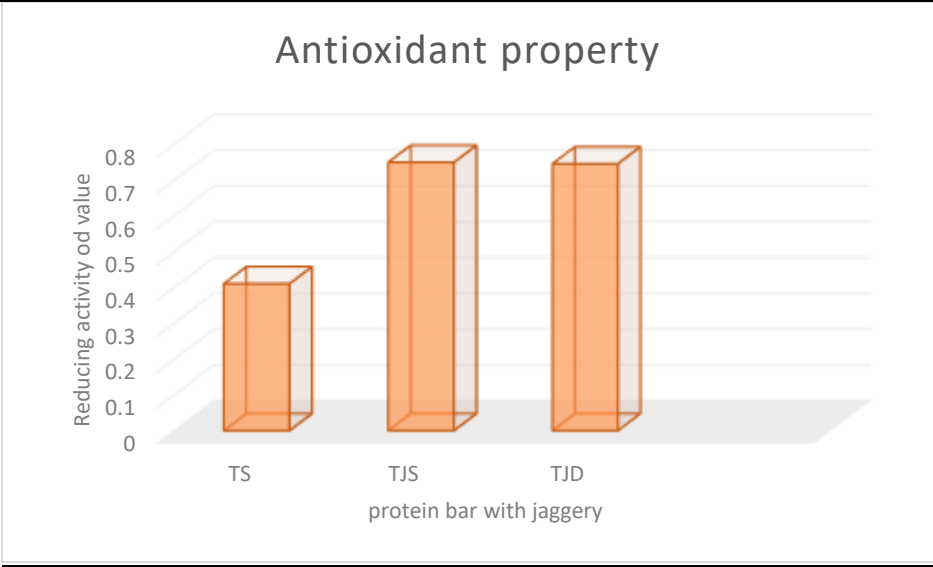


Fig 4: Antioxidant property of Protein Bars

5.7. Antibacterial property:

The antibacterial activity of jaggery was prepared to determine by measuring the diameter of inhibition zone. In case of normal sugar or TS found that the diameter of zone of inhibition against Gram-positive bacteria is 1.8 mm which is higher than gram-negative bacteria which is 1.6 mm. So, that TS sample has high inhibition effect in case of gram-positive organism than gram-negative organism. In case of, protein bar with cane sugar jaggery (TJS) found that the higher inhibitory effect in case of gram-positive bacteria by its diameter detection of 2.2 mm than gram-negative organism. Because TJS are more effective in inhibiting the growth of gram-positive bacteria compared to gram-negative bacteria. So, its observed that gram-positive bacteria were more sensitive to the experimental sample TJS than gram-negative bacteria. The antibacterial activity may be attributed to the polyphenol and antioxidant properties of jaggery.

Table 8: Antibacterial property

SI No	Sample	Diameter of inhibition zone (mm) against gram-positive bacteria	Diameter of inhibition zone (mm) against gram-negative Bacteria
1.	TS	1.8	1.6
2.	TJS	2.2	2.0
3.	TJD	1.1	1.2



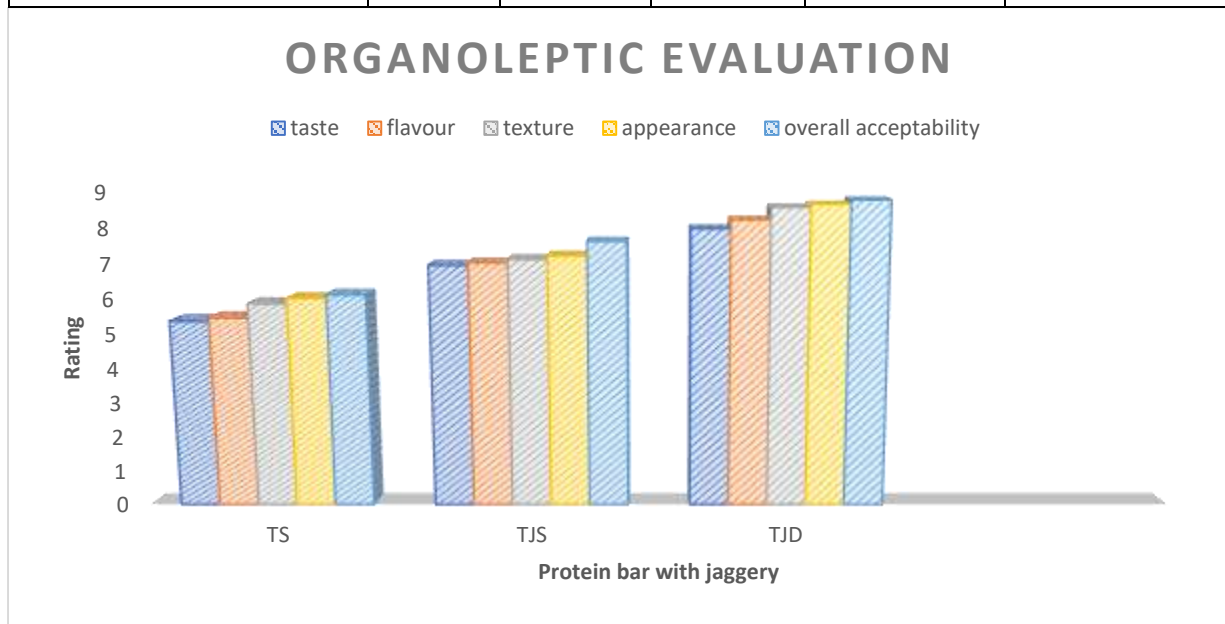
Fig 5: protein bar jaggery of antibacterial property

5.8. Result of organoleptic evaluation:

The jaggery protein bar with 20% jaggery addition were best accepted for equal quantity of beetroot and dates with sensory score for taste, flavour, texture, appearance & overall acceptability were 5.35, 5.44, 5.85, 6.00 & 6.10 respectively. The lowest sensory scores of tastes, flavor, texture, appearance & overall acceptability were for combination with high percentage of beetroot with 6.93, 7.00, 7.10, 7.20 & 7.60. Other common ingredients like groundnuts, oats, pumpkin seeds, chia seeds & flaxseeds were kept constant. The medium sensory of taste, flavour, texture, appearance & overall acceptability were 7.95, 8.20, 8.55, 8.63 & 8.75.

Table 9: Organoleptic evaluation

Sample name	taste	flavour	texture	appearance	Overall acceptability
Control protein bar with sugar (TS)	5.35	5.44	5.85	6.00	6.10
Protein bar with cane sugar jaggery (TJS)	6.93	7.00	7.10	7.20	7.60
Protein bar with date palm jaggery (TJD)	7.95	8.20	8.55	8.63	8.75

**Fig 6: protein bar jaggery of organoleptic evaluation**

6. Conclusion

Protein bars made with cane sugar jaggery and date palm jaggery have better amounts of protein content and fibre content whereas the control protein bar with sugar has more lipid and carbohydrate content. It can be concluded that jaggery rich protein bars are nutrition rich and gut healthy food. In the aspect of micronutrients, there also the protein bars with date palm jaggery have better results, protein bars with date palm jaggery having maximum iron, phosphorus & calcium content among the three bars produced. Protein bars with sugarcane jaggery shows more amounts of magnesium and potassium content. From the results it can be concluded that protein bars made with sugarcane jaggery have maximum antimicrobial activity.

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