PROCESS OPTIMIZATION FOR MANUFACTURING OF SUGAR-FREE HERBAL PEDA

काशी हिन्दू विश्वविद्यालय BANARAS HINDU UNIVERSITY

THESIS

submitted in partial fulfillment of the requirements
for the award of the degree of

Master of Technology
in
Food Technology

Supervisor
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Submitted By
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ID. No. 20412MFT009 **2022** **Enrolment No. 433966**

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The Registrar,
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Dear Sir,

I have great pleasure in forwarding the thesis entitled, **"Process Optimization of Manufacturing of Sugar Free Herbal Peda"** submitted by **Nimbalkar Rajat Ramesh, ID No. 20412MFT009** in partial fulfilment of the requirements for the degree of **Master of Technology** in **Food Science,** Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and placing on record that he has completed the requisite residential requirements as contained in the ordinance of the University.

I certify that the entire scheme of investigation, presented here in, was planned and carried out solely by the candidate under my supervision and guidance. To the best of my knowledge, the data presented in the thesis are genuine and original.

Thanking you

Forwarded Yours faithfully,

…………………
Dr. Ankit Hooda
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(Head of the Department)

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By

Nimbalkar Rajat Ramesh

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Date:

Place: *Varanasi* **(Nimbalkr Rajat Ramesh)**

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ABBREVIATIONS AND SYMBOL

%	Percentage
°F	Degree Fahrenheit
^{0}C	Degree Celsius
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
aw	Water activity
CD (0.05)	Critical Difference at 5.0 percent level
cfu	Colony forming unit
CRD	Completely randomized design
CV	Coefficient of variance
DPPH	2,2-diphenyl-1-picrylhydrazyl
e.g.	*Exempli Gratia*
et al.	And Co-workers
etc.	Etcetera
FFA	Free Fatty Acid
g	gram
GAE	Gallic Acid Equivalents
H_2SO_4	Sulphuric Acid
HCl	Hydrochloric acid
HMF	Hydroxyl Methyl Furfural
hr	hour
i.e.	*id est* (That is)
LSD	Least Significant Difference
mg	milligram

Min	Minute
ml	milliliter
MSNF	Milk solid not fat
N	Normal
O.D.	Optical Density
pH	*Pouvoir hydrogene* (power of hydrogen)
Ppm	Parts per million
Psi	Pound per square inch
SEm	Standard Error of Mean
SPC	Special plate count
TA	Texture Analyzer
TPA	Texture profile analysis
TPC	Total Phenolic Content
Y & M	Yeast and mold

Chapter I

INTRODUCTION

India is the world's leading milk producer, accounting for 19% of the global market share. According to the fiscal year 2019, milk production in India reached approximately 187 million metric tons **(Rajput *et al*., 2021).** Milk, a complete single food available in nature, can serve as the primary source of nutrients for people of all ages **(Patton *et al*., 2017).** As the world's largest milk producer, India accounts for approximately 22% of global milk production. Approximately half of the milk produced in India is converted into traditional Indian dairy products **(Patil, 2002).**

Khoa is a concentrated Indian dairy product from the Indian subcontinent. It is also referred to as *mawa/ khoa*. India's annual *khoa* production is close to 6,00,000 MT, with *khoa* accounting for approximately 7% of total milk production **(Aneja *et al*., 2002).** Approximately half of the milk produced in India (50-55 percent) is used to make traditional dairy-based sweets/products. A significant portion of the milk is converted into indigenous dairy products like *khoa* and khoa-based sweets **(Pandya *et al*., 2008).**

Around 10-15 MT of *khoa* is produced annually out of India's annual milk production of 190 million tones (MT). Uttar Pradesh is the leading *khoa* producing state, accounting for 36% of total production (out of total *khoa* production in India). The yield of *khoa* is primarily determined by the type of milk used and the total solid content of the milk. It is made up of approximately 19% cow milk, 21% buffalo milk, and 20% standardized milk **(Najib *et al*., 2020).**

The root of *Glycyrrhiza glabra Linn,* also called *Mulethi/ AsusSoos*/ licorice sweet wood, is one of the most widely used herbs in ancient medical history, both as a medicine and as a flavoring herb. It has been used to treat respiratory, gastrointestinal, cardiovascular, eye, and skin disorders as an *antiallergic*, demulcent, emollient, and fungicide. It has also been used to treat Addison's disease, rheumatism, osteoarthritis, and arthritis and regulate low blood sugar levels. It is used to treat arthritis and mouth ulcers. **(Ahmed *et al*., 2021).**

The date palm (*Phoenix dactylifera L.)* is a sweet edible fruit in the *Arecaceae* family. Dates have a low-fat content and are thus appropriate for heart patients**.** Dates have a high carbohydrate content (70%) which is ruled by sugars. Dates have a low-fat content (0.2 to 0.5 percent), a high protein content (2.3 to 5.6 percent), vitamins, and are a good source of dietary fiber (6.4 to 11.5 percent). Dates are high in phenolic compounds and antioxidants and minerals such as selenium, copper, potassium, and magnesium **(Hussain *et al*., 2020).** Dates have been shown to have *anticarcinogenic*, *antihyperlipidemic,* and *anti-inflammatory* properties and reduce the effects of hypertension, hyperglycemia, and hyperlipidemia **(Chandrasekaran & Bahkali, 2013).**

People are attempting to use fruits and vegetables in milk and milk products to add value. Various researchers tried adding dried dates to brown *Peda* **(Gotarne, 2011)**, mango pulp to *burfi* **(Shelke *et al*., 2008),** pineapple pulp to *burfi* **(Kamble *et al*., 2010),** dried date to *burfi* **(Pawar, 2011),** and ginger powder to *peda* **(Kumbhar, 2011).**

Different herbs and medicinal plants can be added to normal milk *Peda* to increase medicinal value. Many researchers have worked on herbal milk products in which medicinal plants and herbs have been added to milk to increase nutritional and health value. As a result, milk products like *peda* can be enriched with valuable medicinal phytochemicals like licorice and date powder, which have the health benefits mentioned above.

Earlier research on the incorporation of licorice in ice cream **(Soukoulis *et al*., 2014)** and oils **(Burdock and Isbrucker, 2006)** found that herbs significantly improve the medicinal value and overall acceptability of the finished product.

So far, no research has been conducted on the use of licorice in *Peda*. Given the health benefits of licorice and date powder, it is proposed to investigate the preparation of sugar-free herbal *Peda* using buffalo milk *khoa,* with the following goals in mind.

Objectives

1. Process optimization for sugar-free herbal *Peda* preparation.
2. Identification of the physicochemical and sensory properties of sugar-free herbal *Peda*.
3. Determination of rheological and microbiological properties of sugar-free herbal *Peda*.
4. Calculate the yield and shelf life of sugar-free herbal *Peda*.

Chapter II

REVIEW OF LITERATURE

In India, *khoa*-based products such as *Peda, Rabri, Gulabjamun, Kalakand,* and others are consumed at a higher rate than in other countries around the world. On that basis, many researchers have conducted studies to make many dairy products functional.

The European Union-funded *European Functional Food Science Programme,* led by the *International Life Sciences Institute* (ILSI), defines functional foods as follows **(Kwak *et al.*, 2001):** "A food can be considered 'functional' if it has been satisfactorily demonstrated to affect one or more target functions in the body in a way that is relevant to either an improved state of health and well-being and/or a reduction in disease risk."

2.1 *KHOA*

Concentrated milk products, such as *khoa,* are made using the traditional method of reducing milk volume to 65 percent total solids while continuously stirring in an open shallow pan. Until the milk begins to form dough and begins to leave the vessel's wall, the heating is done in the traditional plants that have been established throughout the country to produce *khoa* mechanically, with a few of them being so mechanized that they produce *khoa* in a continuous process **(Aneja *et al.*, 2002).**

Food Safety and Standards (Food products standards and food additives) Regulations (2011) define *KHOYA* by "whatever variety of names it is sold such as *Pindi, danedar, dhap, mawa* or *kava* means the product obtained from cow or buffalo or goat or sheep milk or milk solids or a combination thereof by rapid drying. The milk fat content shall not be less than 30 percent on a dry weight basis of the finished product. It may contain citric acid not more than 0.1 percent by weight. It shall be free from added starch, added sugar, and added coloring matter."

Depending on the milk used, the color of *khoa* can range from white to pale yellow. Cow milk gives *khoa* a pale-yellow color, while buffalo milk gives it a white color, and it also depends on the type of *karahi* used to make it. Iron *karahi* produces brown to red *khoa*, steel *karahi* produces white *khoa*, and aluminum *karahi* produces green tints. According to the moisture content of *khoa*, it is classified as *Batti khoa* (20% moisture) and *Chikna khoa* (50%) and according to the texture of *khoa*, it is classified as *Danedar, Pindi,* and *Dhap* **(Sawhney *et al.*, 2000).**

Table 2.1 BIS Specification of Different Types of *Khoa*

Constituents ⇩ / Types ⇨	***Dhap***	***Pindi***	***Danedar***
Moisture (%)	45	35	40
Total Solid (%)	55	65	60
Fat (%)	37	37	34
Protein (%)	37	37	37
Ash (%)	6	6	6
Titratable Acid (%)	0.6	0.8	0.9
Coliform count per gram, maximum	90	90	90
Yeast and mold per gram, maximum	50	50	50
Uses for	*Gulabjamun, Pantua.*	*Burfi, Peda.*	*Kalakand,* Milk cake.

Source (Badola *et al.*, 2022)

Dhap khoa is also known as "*Kaccha mava*." *Dhap khoa* has a loose, sticky body and smooth texture and a high temperature and less heat treatment. *Pindi khoa* has the same body and texture as a circular ball of a hemispherical pat. Its properties include cooked flavor, no objectionable odor, and an acidic taste. *Danedar khoa* has a very granular and uneven texture and body. During the preparation process, 0.1 percent citric acid is added **(Sawhney *et al*., 2000).**

Khoa sweets contain essential nutrients and minerals for human health and growth. *Khoa* has a high digestibility and biological value of 90% and 69%, respectively. Iron is deficient in milk and abundant in *khoa* due to the vessel used in the preparation process **(Patton *et al*., 2017).**

The *khoa* yield is primarily determined by the type of milk used and the TS content of the milk. It is approximately 19% cow milk, 21% buffalo milk, and 20% standardized milk **(Najib *et al*., 2020).**

2.1.1 *Khoa* preparation technology

On a large scale, researchers replaced the traditional method of *khoa* production with high-quality steam. They recommend using steam instead of coal or gas, and that replacing traditional iron vessels with stainless steel vessels yields better results **(Ramanna *et al*., 1983).**

When *khoa* preparation equipment was designed, it included a double-jacketed drum with a rotating blade and foam on top of the drum to collect rising foam during the boiling process. He added a steam valve to that equipment to maintain the required steam pressure at various stages of *khoa* production. He compared the time it takes to prepare *khoa* to the time it takes to prepare 1kg of milk. The result of observation was that this process takes 7.5 min **(More, 1983).**

2.1.2 Mechanization of *khoa* production

Scientists mechanized the *khoa* production process. In this process, he heated the milk in a jacketed drum heater that used steam to heat it. Two open pans with scrapers were used to concentrate the milk. The finished product had an unpleasant caramel flavor and a brown color. Contamination in the final stages of this process rendered it unsanitary **(Banerjee *et al*., 1968).**

Also, when the shallow open jacketed pan is equipped with a swinging hanger scraper for continuous milk stirring during the desiccation process. For heating, a jacket half-filled with water was placed over the furnace. A safety valve was installed to keep the temperature and pressure generated by the steam stable. This safety valve adjusts water steam pressure in the range of 0-4 kg/cm^2 and was designed for use in rural areas **(Sawhney *et al*., 1987).**

Researchers examined the chemical composition, sensory properties, and rheology of *khoa* prepared using various processes. They used an inclined scraped-surface heat exchanger (ISSHE), a conical vat, a *contherm-convat* heat exchanger, and a roller drier. Based on the findings, they concluded that the ISSHE method for producing *khoa* had higher sensory values, rheological properties, and chemical composition **(Rajorhia *et al*., 1991).**

2.1.3 *Khoa* Standards and chemical composition:

Table 2.2 shows the FSSAI standards for *khoa* sold in the market.

Table 2.2 FSSAI standards for *khoa*

Components	**Quantity (%)**
Milk fat (%) (min.)	30.00
Total solids (%) (min.)	55.00
Total ash (%) (max.)	6.0
Titratable acidity (% lactic acid) (max.)	0.9

(Source:- FSSAI, 2017)

Note: Please keep in mind that *khoa* samples must be free of added sugar and starch.

When the chemical composition of *khoa* samples made from cow and buffalo milk was examined. Cow milk *khoa* had 74.40 percent TS, 27.24 percent fat, 19.20 percent protein, 25.60 percent lactose, 3.70 percent ash, and buffalo milk *khoa* had

80.70 percent TS, 37.10 fat, 17.80 percent protein, 22.10 percent lactose, and 3.70 percent ash, respectively **(Srinivasan and Ananthakrishnan, 1964).**

The scientist studied the chemical composition of cow and buffalo milk *khoa*, which is shown below **(De, 1980).**

Table 2.3 Chemical composition of cow and buffalo milk *khoa*.

Parameters	Moisture (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)	Iron (ppm)
Cow milk *khoa*	25.60	25.7	19.2	25.5	3.8	105
Buffalo milk *khoa*	19.20	37.1	17.8	22.8	3.6	101

(Source: De, 1980).

Table 2.4 shows the chemical composition and evaluation of *khoa* made from cow milk, buffalo milk, and a cow + buffalo milk blend **(Vijayakhader and Kalpane, 1983).**

Table 2.4 Chemical composition of *khoa* derived from cow milk, buffalo milk, and a blend of cow and buffalo milk.

Parameters	Fat (%)	Protein (%)	Lactose (%)	Ash (%)	Total solids (%)
Cow milk *khoa*	25.20	15.80	33.50	4.10	80.70
Buffalo milk *khoa*	30.50	17.70	23.90	5.90	78.40
Cow + Buffalo milk *khoa*	29.00	16.70	30.10	5.20	79.80

(**Source**: **Vijayakhader and Kalpane, 1983**).

They used traditional and continuous methods to compare the chemical composition of *khoa* produced using two different methods. They concluded from the findings that the continuous method has several advantages over the traditional method. **(Verma and Dodeja, 2000).**

The characteristics of soy *khoa* and standardized cow milk blending were evaluated. The finished product has approximately 35-37 percent moisture, 62-65 percent total solids, 17-19 percent protein, 17-21 percent fat, 2-4 percent ash, and 0.29-0.42 percent acidity. The addition of soymilk increases protein, antioxidants, and phenols while decreasing fat, ash, and acidity **(Pratap *et al*., 2019).**

Khoa samples derived from camel milk, cow milk, and buffalo milk were compared. Camel milk *khoa* had higher moisture, ash, acidity, soluble nitrogen, free fatty acid, 5-HMF, and peroxide values than cow or buffalo milk *khoa*. Buffalo milk *khoa* had higher fat, protein, SNF, lactose, and yield values. Cow milk was relatively high in all of these components **(Chaudhary *et al*., 2017)**

The composition of *khoa* at various acidity levels of cow and buffalo milk was investigated. Acidic milk contained 0.18 percent LA, and sodium bicarbonate was used to neutralize the milk. Table 2.5 shows the chemical composition profile that they observed **(Choudhary *et al*., 2017).**

Table 2.5 Chemical composition of *khoa* is derived from fresh, acidic, and neutralized cow and buffalo milk

	Fat (%)	Protein (%)	Lactose (%)	Moisture (%)	Ash (%)	TS (%)	pH (%)	Acidity (%)
FCMK	26.46	18.30	24.87	29.65	3.24	70.35	6.40	0.63
ACMK	26.13	18.43	21.53	27.07	3.17	72.92	6.22	0.68
NCMK	25.19	19.03	20.80	30.75	3.46	69.25	6.51	0.58
FBMK	35.13	17.56	20.59	23.94	2.74	76.06	6.48	0.57
ABMK	35.50	17.70	17.66	22.43	2.64	77.57	6.38	0.62
NBMK	35.41	17.76	17.03	25.44	2.85	74.56	6.68	0.55

(**Source**: **Choudhary *et al*., 2017**).

FCMK: Fresh Cow Milk *Khoa*, FBMK: Fresh Buffalo Milk *Khoa*,

ACMK: Acidic Cow Milk *Khoa*, ABMK: Acidic Buffalo Milk *Khoa*,

NCMK: Neutralized Cow Milk *Khoa* NBMK: Neutralized Buffalo Milk *Khoa*.

2.1.4 Physical properties of *khoa*:

Table 2.6 shows the difference in sensory properties of *khoa* prepared from cow and buffalo milk **(De, 1980).**

Table 2.6 Comparison between sensory properties of cow milk *khoa* and buffalo milk *khoa*

	Color	Appearance	Body	Texture	Smell	Taste	Suitability
Cow milk *khoa*	Pale yellow with a brown tinge	Wet surface (High moisture)	Hard	Sandy	Nutty and rich	Little bit salty	Less suitable for sweets
Buffalo milk *khoa*	Whitish With brown tinge	Oily/greasy surface	Soft	Smooth and granular	Nutty and rich	Slightly sweet	More suitable for sweets

(**Source**: **De, 1980**)

According to scientists, *khoa* has a distinct mild cooked flavor that resembles slightly overheated milk, is free of intense flavor, and has a granular texture. It must have a brown tinge to it. Cow milk *khoa* was yellow to deep yellow and had free fat on the surface, both of which were desirable **(Pal and Gupta, 1985)**

Some researchers worked on making *khoa* from lactose-hydrolyzed milk so that lactose-intolerant people could consume it. The physicochemical and textural properties of low lactose *khoa* were discovered to be superior to those of an over-controlled sample **(Aggarwal *et al*., 2019).**

The effect of the *Maillard* reaction and protein oxidation on milk quality was investigated when preparing *khoa* from cow and buffalo milk. According to this study, as the heating intensity of boiled milk and *khoa* increased, so did the concentration of browning indicators and protein-bound carbonyls. Buffalo milk had a higher *Maillard* reaction effect and a higher protein-bound effect. Browning and protein-bound carbonyls were increased in milk and *khoa* after neutralization **(Choudhary *et al*., 2017)**

2.1.5 Microbiological properties of *khoa*

The microbial properties of *khoa* were first investigated by researchers. Their research focused on the external sources that cause mold contamination. The main source of contamination was identified as contaminated utensils, a lack of good storage technologies, improper handling, and so on **(Bhat *et al*., 1948)**

The safe limit of coliform, yeast and mold count in per gram of *khoa* sample was established by the **Bureau of Indian Standards (BIS)** in 1980. The maximum limits for the coliform count and yeast and mold should be 90/gm and 50/gm, respectively.

Microbial colonies were found in *khoa* samples collected from a local market in *Karnal*, Haryana. The samples were contaminated with yeast and mold coliform. The standard plate count was 1.3×10^3 – 1.5×10^5, the yeast and mold count was 50-56×10^3, and the coliform test was positive **(Naidu and Ranganathan, 1965).**

SPC, yeast, and mold were detected in a *khoa* sample prepared in the laboratory. They record SPC of 8.0×10^3-2.1×10^4/gm and YMC of 10-30/gm. There were no coliforms or staphylococci in that sample **(Kumar *et al*., 1975).**

2.1.6 Packaging and Shelf Life of *khoa*

Researchers applied sodium propionate to butter paper, which increased the shelf life of *khoa* at room temperature for up to 5 days and 50° C for up to 20 days.

Under normal conditions, the shelf life of *khoa* packed in normal butter paper at 50°C was 16-18 days **(Jalil *et al*., 1963).**

Some people suggested wrapping *khoa* in 30% potassium sorbate-treated butter paper. They claimed that *khoa* wrapped in it has a shelf life of 45 days at 50^0 Celsius **(Ghodekar *et al*., 1978)**

Synthetic antioxidants, according to some researchers, reduced the development of rancidity during *khoa* storage. As a result, the addition of Butylated Hydroxy Anisole and Butylated Hydroxy Toluene can extend the shelf life of *khoa* by 30 days **(Rehman *et al*., 2006).**

Scientists investigated the effect of maltodextrin as a humectant on lowering water activity in *khoa* to increase its shelf life. Water content was increased at higher levels of maltodextrin monolayer, as well as bound water and sorption surface area. They eventually concluded that maltodextrin could be beneficial in improving *khoa* storage quality **(Ahmad *et al*., 2008).**

2.2 Licorice

Glycyrrhiza glabra Linn. belongs to the *Leguminosae* family and is a genus of perennial herbs and under shrubs found throughout the world's subtropical and warm temperate regions. *Glycyrrhiza glabra Linn* generally known as *Jothimadh*, *Mulethi* in Hindi, *Yashtimadhuh*, *Madhuka* in Sanskrit, *Jashtimadhu*, *Jaishbomodhu* in Bengali, *Atimadhuranu, Yashtimadhukam* in Telugu, *Jethimadhu* in Gujarati, and *Atimaduram* in Tamil (**Chopra *et al*., 2002).**

Licorice extracts and their main component, glycyrrhizin, are widely used in foods, tobacco products, traditional medicine, and herbal medicine. It is grown for its underground stems, which contain the compound glycyrrhizin, which is 50 times sweeter than sugar **(Meena *et al*., 2010).**

2.2.1 Chemical components

More than 400 chemical compounds have been isolated from *Glycyrrhiza* species; the compound is composed of triterpene *saponins*, flavonoids (*liquiritoside, isoliquiritoside*), and was thought to be responsible for licorice's bioactivities. Because of differences in plant species and geographic sources, the contents of these *saponins* and flavonoids can vary significantly. Polysaccharides, pectins, steroid hormones, saccharose, glucose, amino acids, and mineral salts are all examples of polysaccharides **(Obolentseva *et al*., 1999)**

The main component in the *Glycyrrhiza* plant is roots and stolon imparted a sweet flavor. Glycyrrhizin is a triterpene *saponin* of the *oleanane* class. This compound was a mixture of potassium-calcium-magnesium salts of *glycyrrhizic acid* that ranged from 2 to 25 percent. *Glycyrrhizic acid,* a natural saponin, was a molecule composed of a hydrophilic part, two molecules of glucuronic acid, and a fragment, *glycyrrhetic acid* **(Obolentseva, 1999).**

2.2.2 Health benefits of licorice

Traditional uses

- *Glycyrrhiza glabra Linn.* is a highly commercially important target species that has been widely used in folk medicine. *G. glabra* roots and rhizomes are used as anti-inflammatory agents in the treatment of allergic reactions, as well as antimicrobial, antiulcer, expectorant, and anxiolytic properties in traditional medicine **(Wang & Han, 1993; Asl & Hosseinzadeh, 2008).**

- It has also been used to treat Addison's disease, rheumatism, osteoarthritis, and arthritis and regulate low blood sugar levels. It is used to treat arthritis and mouth ulcers. **(Indian Commonwealth, 1985; Bradley, 1992.)**

- It has also been used to treat respiratory, gastrointestinal, cardiovascular, eye, and skin disorders, as well as for its antiviral properties.

- The root extract had mild estrogenic effects and has been shown to help some people with menopausal symptoms, menstrual cramps, and menstrual regulation. *Glycyrrhiza glabra* roots and rhizomes have been used in clinical practice for centuries to treat liver diseases and are a major component of polyherbal formulations for the treatment of hepatotoxicity, anti-allergic, demulcent, emollient, fungicide, peptic ulcer to prevent liver toxicity, tuberculosis, and adrenocortical insufficiency **(Badkhane *et al*., 2014).**

Medicinal Uses

- Cough suppression, treatment of early Addison disease, treatment of liver disease and dyspepsia, as well as prophylaxis and treatment of gastric and duodenal ulcers are all medicinal uses of licorice.

- Licorice is a sweet, moist, and soothing herb that is anti-inflammatory and used to treat arthritis and mouth ulcers. Demulcent for sore throats, expectorant for coughs, and widely used in cough medicines for bronchial catarrh.

- Licorice preparations have been used to soothe and heal skin eruptions such as skin diseases and herpetic lesions. Antispasmodic, demulcent, diuretic, emollient, expectorant, laxative, pectoral, and tonic properties of the root. The root has also been shown to have a similar hormonal effect to ovarian hormone **(Badkhane *et al*., 2014)**

- Research has shown that it has antibacterial, anticancer, anticoagulant, antifungal, antihyperglycemic, anti-inflammatory, antimalarial, antioxidant, antitussive and expectorant, antiulcer, antiviral, hepatoprotective, immunomodulator, memory enhancing, and skin lightening properties. The majority of traditional medicine's claims have been proven by scientific studies. These findings are very encouraging and suggest that this drug should be studied further to confirm other potential therapeutic effects**. (Ahmed *et al*., 2021).**

2.3 Date Powder

The date palm (*Phoenix dactylifera L.*) is a sweet edible fruit in the *Arecaceae* family. Dates have a low-fat content and are thus suitable for heart patients who can consume dates or their products in various forms. Date production in the world exceeds 7 million tons per year **(Dhankar *et al*., 2021).**

Dates can be eaten dry or soft, seeded and stuffed, or chopped and used in a variety of ways, including cereal, pudding, bread, cakes, cookies, ice cream, or candy bars. In factories, pitting can be done by crushing and sieving the fruits or, more sophisticatedly, by piercing the seed out and leaving the fruit whole. The calyces can also be removed mechanically. Dates that are in excess are processed into cubes, paste, spread, powder (date sugar), jam, jelly, juice, syrup, vinegar, or alcohol. Date juice that has been discolored and filtered, yields a clear invert sugar solution **(El-Sohaimy *et al*., 2010)**

2.3.1 Chemical composition of date

Dates are mostly made up of carbohydrates (about 60%), the majority of which are sugars. Dates have a high carbohydrate content (70%) that is dominated by sugars. Invert sugar is the primary sugar found in dates, which also contain glucose and fructose. Glucose is advantageous because it is the most readily available source of energy **(Myhara *et al*., 1999; Liu *et al*., 2000).**

It is also high in dietary fiber, vitamins, carotenoids, anthocyanins, phenolics, and antioxidants. Fructose, being sweeter than glucose (almost twice as sweet), creates a feeling of fullness in the consumer, lowering calorie intake in comparison to a fat-rich diet. Dates are a high-energy food source. Dates have a low-fat content (0.2 to 0.5 percent), a high protein content (2.3 to 5.6 percent), vitamins, and are a good source of dietary fiber (6.4 to 11.5 percent). Dates are high in phenolic compounds and antioxidants, as well as minerals such as selenium, copper, potassium, and magnesium **(Iftikhar *et al*., 2015).**

2.3.2 Health Benefits of date

Dates have been shown to help diabetic patients with hypertension, hyperglycemia, and hyperlipidemia **(Appel *et al*., 1997).**

Dates have anti-inflammatory, anti-cancer, nephroprotective, and hemolytic properties. Dates have long been used in traditional medicine to treat or prevent colds, sore throats, fevers, abdominal problems, and reproductive system problems **(Raza *et al*., 2019)**

Dates are an excellent substitute for added sugar in foods due to their higher natural sugar content and bioactive compounds. According to scientific evidence, increased consumption of added sugar (refined white sugar) raises the risk of overweight and obesity, as well as other risk factors for cardiovascular disease such as dyslipidemia and high blood pressure **(El-Sohaimy *et al*., 2010).**

The World Health Organization (WHO) recommends limiting added sugar consumption to less than 10% of total energy. Similarly, the American Heart Association recommends that women limit their daily added sugar intake to 100 calories and men limit it to 150 calories.

Dates have been used to replace added sugar in a variety of food preparations. Date syrup or paste was used in the making of muffins, ice cream, yogurt, pan bread, *idli*, and other baked goods. However, the reformulated products' qualities, particularly their texture and color, were compromised **(Raza *et al*., 2019).**

2.4 *PEDA*

The plain *peda* is also known as *dudh peda/*plain *peda/*white *peda* in general. Over many decades, this has been recognized as *Prashad*. This *Peda* is added to *lassi* in some parts of Punjab to make it sweeter and more nutritive.

Researchers discovered that people in northern and western India prefer white *peda* made from buffalo milk over other types of *peda*. *Peda* is a *khoa*-based indigenous milk product that is more popular than other *khoa*-based sweets in the Indian subcontinent. This milk product is thought to have originated in Mathura, Uttar Pradesh **(Patel, 1986)**

There are numerous varieties of *Peda* found in India, and each variety becomes the identity of that location. Several examples are as follows:

***Brown Peda*:** Also known as 'Mathura *Peda'* in Uttar Pradesh. The distinctive brown color of this *Peda* is the result of cooking *khoa* in ghee and then blending it with sugar. Its caramel flavor and longer shelf life make it more popular **(Londhe *et al*., 2012)**

***Dharwad Peda*:** This *Peda* variety originated in the Karnataka district of Dharwad. It has a history of about 175 years **(Thakur, 2016).** It was given a GI tag. Initially, it was made with *Dharwadi* buffalo milk **(Prakash, 2011).**

***Kandi Peda*:** Originated in Maharashtra's *Satara* district. It is a Maharashtrian sweet with a round, smooth texture that is mostly flavored with cardamom or saffron.

***Thirattipal peda*:** *Thirattipal* is a Tamil word derived from *Srivilliputhur*. "*Thirattu*" means "constant stirring of material for condensation" in their native language, and "Pal" means "milk." *Thirattipal* texture is achieved through partial coagulation of milk prior to the addition of sugar.

***Lal Peda*:** This *Peda* is thought to have originated in the Varanasi district of Uttar Pradesh. Blending *khoa* with sugar, then heating continuously until the reddish-brown color appears.

***Thabdi Peda*:** Gujrat Saurashtra region.

Scientists investigated various types of *Peda* made from *khoa* and discussed various aspects of milk *Peda*. Table 2.7 summarizes the findings of various aspects of that study **(Patel, 1986).**

Table 2.7: Different aspects of milk *Peda*.

Aspects	Results
Color	Creamy or white
Thickness (cm)	1.81 +_ 0.11
Diameter (cm)	4.16 +_ 0.05
Weight (cm)	23.65 +_ 0.11
Density (g/cm^3)	1.13 +_ 0.10
Geometric Mean Diameter (cm)	4.16 +_ 0.041
Sphericity	0.95 +_ 0.021
Roundness	0.95 +_ 0.094
Fat (%)	15.12 +_ 0.26
Moisture	22.90 +_ 0.23
Hardness (N)	13.93
Adhesiveness (N)	-0.19
Springiness (mm)	0.06
Cohesiveness	0.07
Gumminess (N-mm)	1.22
Chewiness (N-mm)	0.08
Resilience	0.03

Source: (**Patel, 1986**)

2.4.1 Chemical composition of milk *Peda*

In India, milk Peda is primarily produced by *halwais,* and as a result, neither FSSAI nor BIS have established chemical composition standards for milk *Peda*. However, apart from that, many researchers have tested many samples of milk *Peda* collected from the local market as well as prepared in the laboratory under controlled conditions.

When *khoa* from buffalo milk was prepared and analyzed, its chemical composition was determined. The moisture, protein, lactose, fat, sucrose, and ash (percent) contents of the prepared sample were 10.28, 19.00, 18.33, 20.10, 30.00, and 2.24, respectively **(Patel, 1986).**

Peda samples were also collected and analyzed from a few districts in Gujarat state. 8.68-16.52 percent moisture, 14.92-23.92 percent fat, 13.17-15.80 percent protein, 13.95-17.19 percent lactose, 32.10-39.23 percent sucrose, and 2.04-2.80 percent ash were discovered **(Patel, 1986)**

Peda samples made from cow and buffalo milk were compared, and the results are shown in table no. 2.8.

Table 2.8 Chemical composition of *Peda* samples from cow and buffalo milk.

	Moisture (%)	Fat (%)	Protein (%)	Lactose (%)	Sucrose (%)	Ash (%)
Cow milk	16.25±1.25	23.83±0.85	15.86±0.15	14.67±5.5	29.32±1.10	2.46±0.02
Buffalo milk	14.65±1.03	31.74±0.93	16.79±0.12	15.83±0.38	21.54±1.53	2.87±0.01

Source: (**Ray *et al*., 2002**)

2.4.2 Microbiological quality of milk *Peda*

The presence and growth of microorganisms, particularly Coliform and other bacteria that cause food poisoning, were investigated in *Peda*. He kept two *Peda* samples, one in the open and one in glass cases. According to the results, *Peda* samples in open space had more microbe growth than samples in glass cases. Pathogens such as *E. coli*, *Salmonella schottmuelleri*, *Pseudomonas aeruginosa*, and others contaminated the water**. (Patel, 1985).**

When *Peda* samples from *Hisar* local market were collected and studied for microbial contamination. He measured SPC 1.1×10^{3}-5.6×10^{6}/gm, Y&M 1-3×10^{2}/gm, coliform 1.3×10^{3}/gm, *faecal coli* 0-50/gm, and staphylococci 0-3×10^{5}/gm. (**Garg, 1981).**

When *Peda* samples from Mysore's local market are tested. The contamination range was 7.6×10^2-5×10^3/gm SPC, 1.42×10^4-9.4×10^4/gm Y&M, 0-460/gm coliform, and 0-240/gm staphylococci. **(Dwarkanath and Srikanta, 1977)**

2.4.3 Packaging and shelf-life milk *Peda*

Brown *Peda* samples were prepared and packed at 30^0 Celsius using three different packaging techniques: cardboard boxes, modified atmospheric packaging, and mold vacuum packaging. Based on the results, they concluded that mold vacuum packaging was superior to the other two packaging techniques. The maximum shelf life of vacuum packaging was 40 days. **(Londone *et al*., 2012)**

When changes in the properties of *Lal Peda* were studied during storage at different temperatures in paper boxes, they discovered that the FFA and HMF content in samples increased and that these changes were temperature-sensitive. They concluded that samples stored at 40°C had greater overall acceptability (31 days) than samples stored at 37°C based on textural and sensory parameters (9 days) **(Jha *et al*., 2014)**

They investigated the effect of MAP on *Lal Peda* shelf life. They stored *Lal Peda* samples in three different polyethylene bags filled with varying levels of gaseous concentration. The results showed that samples packed in a 70% N_2:30% CO_2 combination of gases had a longer shelf life than other packed samples **(Jha *et al*., 2015).**

MATERIALS AND METHODS

The work related to this research topic was completed in the PG laboratory of the Department of Dairy Science and Food Technology, Institute of Agriculture, Banaras Hindu University, Varanasi, India.

This experiment covers the study on the development of technology for sugar-free herbal *Peda*. This chapter deals with the materials and methodologies employed during the present study. It involves varying levels of replacement of sugar with date powder which influences the quality of the product. The experimental and control samples were evaluated for proximate, physiochemical, sensory and microbial analysis. The various materials used during the course of this investigation were encompassed hereunder.

3.1 MATERIALS/ INGREDIENTS

Different types of materials are used in the manufacturing of sugar-free herbal *Peda* are as follows

3.1.1 Buffalo Milk

Buffalo milk of 6% fat and 9% SNF was procured from *Amul* parlour, BHU campus, Varanasi.

3.1.2 Licorice powder

Good quality licorice powder was purchased from Flipkart.

3.1.3 Date powder

Good quality packaged dry dates were purchased from the shop in Lanka and powder was prepared from it in the pilot plant.

3.1.3.1 Method for preparation of date powder

Firstly, dry dates were spread in trays evenly to remove excess water. Then dry dates were put in a tray drier at 50–55ºC till a 5- 6% moisture level was reached. After drying, dry dates were ground into powder form then the powder was sieved and packaged in polythene bags at room temperature for further preparation of herbal *Peda* without added sugar.

3.1.4 Ghee

Cow ghee was taken from the *Amul* milk shop on the BHU campus. Ghee was required for greasing of steel tray and paperboard boxed so that *Peda* should not stick to their surface.

3.1.5 Chemicals

Almost all of the chemicals utilized in this research work were of analytical grade. HI Media Laboratories Pvt. Ltd. (Mumbai, India), Merck Specialties Pvt. Ltd, (Mumbai, India), Fisher Scientific, (Mumbai, India) were the source of the chemicals.

3.1.6 List of instruments used during research work

Different types of instruments are used in the manufacturing of sugar-free herbal *Peda* as mentioned in table 3.1. *Karahi, kunti,* steel tray, and cardboard boxes are also used.

Table 3.1 List of instruments used during research work

Name of instrument	Company, model, and country
Electronic weighing balance	Metllertoledo, jbi 603 Switzerland
Digital pH meter	Thermo scientific sn821899, Singapore
Kjeldahl apparatus	KELPULS-ELITE EX (VA)
Soxhlet apparatus	SOCS PLUS, SCS-4, Chennai
Texture profile analyzer	Brookfield Analyzer
Tray dryer	KHORA
Laminar Air Flow	Lab tech lcb 1201v, daihan pvt. ltd. India
Centrifuge machine	Sigma, 3-30k, Germany
Incubator	Remi, India
UV- spectrophotometer	Shimadzu UV-1800, JAPAN
Autoclave	Tommy SX-500, UK
Hot air oven	Per fit, 992110, India

3.2 METHODS

Sugar-free herbal *peda* was prepared by using the different treatments and procedures mentioned below.

3.2.1 Preparation of sugar-free herbal *Peda*

For the preparation of sugar-free herbal *Peda* buffalo milk (6% fat & 9 % SNF) was procured. After preparing *khoa*, licorice and date powder were added to it in different proportions to study the changes in different parameters of sugar-free herbal *Peda*. Sugar used in the manufacturing of *Peda* was replaced by date powder.

FLOW CHART OF SUGAR-FREE HERBAL *PEDA*

Procured buffalo milk (6% fat & 9 % SNF)

↓

Filtration

↓

Preheating (38-40^{0}c)

↓

Boiling of milk in a *karahi* (stirring and scrapping)

↓

Khoa leaving sides of the pan

↓

Pat formation stage (stop heating)

↓

khoa

↓

Take in pan

↓

Fry for about 2-3 min. until it melts & raw smell of it get vanished

↓

khoa melt and begins to start release ghee

↓

Mix well

↓

Fry on medium heat until it comes together like dough, for 8-10 min.

↓

Stir the mixture continuously

↓

Take the little mixture with a spoon & check

↓

If it comes together like dough, the mixture is ready to make *Peda*.

↓

Turn off gas

↓

Add licorice and date powder at a given proportion

↓

Continuous stirring for about 1-2 min., after turning off gas

↓

Transfer the mixture to the dish

↓

Spread it

↓

Let mixture cool down completely

↓

Roll mixture into *Peda*

↓

Keep for overnight to get the perfect *Peda*

↓

SUGAR-FREE HERBAL *PEDA* is ready

↓

Packed in suitable packaging material & stored at room temperature

Fig. 3.1 Preparation of sugar-free herbal *Peda*

3.2.2 Treatment Detail of sugar-free herbal *Peda*

For the preparation of sugar-free herbal *Peda* different proportions of licorice and date powder were used to study the sensory, *Physico-chemical*, textural and microbiological properties of *Peda*. Different proportions of *khoa*, date powder and licorice are used as per table 3.2

Fig. 3.2 Sugar-free herbal *peda* samples of different treatments

Table 3.2 Designation of sugar-free herbal *Peda* prepared by replacement sugar with licorice and date powder (% w/w of milk) at selected levels

Designation of the experimental sample (s)	***Khoa* (g / 100g)**	**Date powder (g / 100g)**	**Licorice (g / 100g)**
T0 (control)	70	30 (sugar)	-
T1	65	30	5
T2	60	36	4
T3	60	30	10
T4	55	0	5
T5	50	45	5
T6	45	45	10

3.2.3 Yield estimation of sugar-free herbal *peda*

The yield was estimated by the ratio of weight of the final product to the weight of raw materials taken. In case of sugar-free herbal *peda* raw materials used are milk, date powder and licorice powder.

$$\textbf{\% Yield} = \frac{Wt.\ of\ sugar\text{-}free\ herbal\ peda}{Wt.\ of\ raw\ material} \times 100 \qquad \ldots (Eq^n.\ 1)$$

3.2.4 Rheological analysis of sugar-free herbal *peda*

Rheological properties were tested by a “texture analyzer” (Brookfield Texture Analyzer) Rheological properties of *Peda* which were tested are hardness, cohesiveness, gumminess, chewiness, adhesiveness, and springiness. Further details of these rheological properties are mentioned in the appendix VIII.

Fig. 3.3 Brookfield Texture Analyzer

Table 3.3 Texture analyzer setting of "Brookfield Texture Analyzer" for analysis of sugar-free herbal peda

Mode	Measure force in compression
Option	Return to start
Pre-test speed	1.5 mm/s
Test speed	10 mm/s
Post- test speed	10.0 mm/s
Distance	5.0 mm/s
Trigger force	Auto – 25 g
Tare force	Auto

3.2.5 Physico-chemical analysis of sugar-free herbal *peda*

Various *Physico-chemical* properties were tested by using different methods. Properties and their respective methods are listed below.

3.2.5.1 Moisture analysis of sugar-free herbal *peda*

Moisture analysis of sugar-free herbal *Peda* is determined by the method (AOAC, 1980) is as follows:

A weighed sample of finely ground material (5g) is dried in a hot air oven for 8 hours at 105°C. In the case of a wet sample, it is dried to constant weight. Crucible with dried material is transferred immediately to a desiccator, cooled, and weighed.

$$\textbf{\% Moisture content} = \frac{W3 - W1}{W2 - W1} \times 100 \quad \ldots (Eq^n.\ 2)$$

Where,

W1 = Weight of empty petri-plate

W2 = Weight of empty petri-plate + Sample

W3 = Weight of petri-plate after drying

3.2.5.2 Ash content determination of sugar-free herbal *peda*

Ash content analysis of sugar-free herbal *Peda* is determined by the method (AOAC, 1980) is as follows:

One gram of a completely homogenized sample was taken accurately in a moisture-free silica crucible. The crucibles were then placed on the hot plate at 130^0c till the smoke disappeared. The crucibles were then placed in a muffle furnace at 550 ^{0}c (6 h.). Weights of the cooled crucibles were noted down.

$$\textbf{\% Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100 \quad \ldots (Eq^n. 3)$$

3.2.5.3 pH determination of sugar-free herbal *peda*

The pH of sugar-free herbal *Peda* was measured using a digital pH meter. The method described by **Franklin and Sharpe (1963)** for cheese was used. The homogenate prepared by diluting 20 g of sample in 20 ml of glass distilled water was subjected to pH measurement.

3.2.5. Protein determination of sugar-free herbal *peda*

The protein content in the sugar-free herbal *Peda* was estimated by following the protocol of AOAC (2000).

1. Digestion

The system was switched ON, and the digestion unit was pre-heated up to 350 ^{0}c. 0.2 g sample was weighed (W) in the filter paper and wrapped inside it, in triplicates. The sample was taken in a 250 ml Macro DTL tube. Then to the sample, 10ml conc. H_2SO_4 was added, followed by the addition of 5g of catalyst mixture [(5:1) (*Potassium Sulphate: Copper Sulphate*)].

The sample tube was then loaded in the digestion unit with manifold & KEL FLOW setup. Tap water was connected with maximum pressure for KEL FLOW. The temperature was increased to 420^{o} C. Digestion was carried out till clear green color appeared. According to the sample, ninety minutes were taken for digestion. Then the digested mixture was cooled on the cooling rack for approximately thirty minutes.

2. Distillation

The system was switched ON and the solutions *viz*. 4% Boric acid, 40% Alkali, and 0.1N *HCl* were prepared and kept. The Alkali, Boric acid, and $KMnO_4$ were loaded into the system through silicon hoses provided at the back of the equipment while waiting for the ready signal. In a 250 ml conical flask 25ml, Boric acid was taken with an indicator and placed at the receiver end.

The sample was diluted with distilled water (dilution of 10 ml to 20 ml). Then the sample tube was loaded on the sample side. Before starting the sample testing, the water was allowed to flow through the system for cooling purposes (check the INLET and the OUTLET). The sample testing was started after the READY signal appeared. 40 ml of the 40% Alkali was added to the above (until dark brown color appears). Then the process was started.

During the process, liquid ammonia was collected into Boric acid and its color changed according to the indicator used. After the completion of the process, the conical flask was removed from the receiver end and then titrated. The tube from the sample side was now removed.

3. Titration

0.1N *HCl* was taken in the burette and titrated first against blank and then against the sample. *Titre value* was noted down.

Calculations

$$\textbf{\% Nitrogen} = \frac{14.01 \times 0.1N \times (TV - BV)}{W \times 1000} \times 100 \quad \ldots (Eq^n. 4)$$

$$\textbf{\% Protein} = \% N \times 6.25 \text{ (for food samples)} \quad (Eq^n. 5)$$

Where,

TV = *Titre value*

BV = Blank value

W = Sample weights

3.2.5.5 Fat analysis of sugar-free herbal *peda*

Fat analysis of sugar-free herbal *Peda* is determined by (IS: 1011: 2002) method is as follows:

Two grams of sugar-free herbal *Peda* sample were taken in a thimble and the thimble was placed in a previously weighed *soxhlet* beaker. The beakers were then placed in the extractor (*SocsPlus*). After that extractor was filled with petroleum ether and its top was covered with cotton plugs. The *Soxhlet* apparatus (SOCS PLUS, SCS-4, Chennai) was then switched on with a set temperature of 70 °C for 90 minutes. After completion of extraction, the temperature was increased up to 150°C again for 90 minutes, for the complete removal of moisture. The beakers were removed from the *Soxhlet* apparatus and cooled in a desiccator. The cooled beakers were then weighed.

Calculation

$$\% \textbf{\textit{Fat}} = \frac{\textit{Weight of residue}}{\textit{Weight of sample}} \times 100 \quad \ldots (Eq^n.\ 6)$$

Where,

Weight of residue = (Weight of beaker after drying – Weight of empty beaker)

3.2.5.6 Estimation of total carbohydrates:

Total carbohydrate content of sugar-free herbal peda was determined by subtracting fat, proteins and ash content from the total solids content.

$$\% \textbf{\textit{Total Carbohydrate}} = \% \textbf{\textit{Total solids}} - (\%\textbf{\textit{Fat}} + \%\textbf{\textit{Protein}} + \%\textbf{\textit{Ash}})$$

3.2.5.6 Antioxidant activity determination of sugar-free herbal *peda*

Determination of the antioxidant activity of the sample was done by the DPPH inhibition method **(Nishino *et al*., 2000).**

1 g finely ground Sample was taken in 10 ml methanol and was kept overnight in dark at room temperature. 0.1 ml of eluted extract was taken and to it 0.25 ml of DPPH solution (80 µg/ml methanol) followed by 2 ml of methanol. A control blank was set up with 2.1 ml distilled water and left at room temperature for 30 min. The sample sets were centrifuged at 6000 rpm for 20 min. A cuvette was filled with 0.5 mL of centrifuged solution and 1 mL of methanol. Using methanol as a reference, absorbance was measured at 517 nm individually for the blank and samples.

$$\% \textbf{\textit{DPPH inhibition}} = \frac{AB\text{-}AS}{AB} \times 100 \quad \ldots (Eq^n.\ 7)$$

Where,

AB = OD for blank

AS = OD for sample.

3.2.6 Microbial analysis of sugar-free herbal *peda*

Microbial aspects like Total Viable Count, Yeast and Mold count, and Coliform test were analyzed by using various agars and techniques.

Table 3.4 Microbial analysis and agars for it.

S.No.	Microbial tests	Agar used
1.	Total Viable Count	Plate Count Agar
2.	Yeast and Mold count	Potato Dextrose Agar
3.	Coliform test	Violet Red Bile Agar

3.2.6.1 SPC (standard plate count) of sugar-free herbal *peda*

1 gm sample was diluted with sterile distilled water and homogenized and used as stock solution. One ml sample stock solution was further diluted with 9 ml sterile water in a test tube. From this diluted stock solution, a series of subsequent 10-fold dilutions ranging from 10^{-1} to 10^{-6} was prepared.

The media for the total plate count of micro-organisms was prepared. 23.9 g total plate count agar is mixed with 1liter sterile distilled water. The mixture was boiled for dissolving completely and was sterilized in an autoclave at 121°C temperature (15 psi pressure for 15 min). The media was then cooled at 40°C and distributed to Petri dishes. *Peda* sample dilutions were taken in different Petri dishes and agar medium was added to each dish, these were then covered and labeled and kept in an incubator for 3 days at 25^0C and then total bacterial colonies were calculated.

3.2.6.2 Yeast & Mold count of sugar-free herbal *peda*

The media for yeast and mold count was prepared. 44 gm potato dextrose agar is mixed with 1 liter sterile distilled water. 1% tartaric acid is added to the solution. The mixture was boiled for dissolving completely and was sterilized in an autoclave at 121°C temperature (15 psi pressure for 15 min). The media was then cooled at 40°C and distributed to Petri dishes. *Peda* sample dilutions were taken in different Petri dishes and agar medium was added to each dish, these were then covered and labeled and kept in an incubator for 3 days at 25^0C and then yeast and mold counts were calculated.

3.2.6.3 Coliform count of sugar-free herbal *peda*

The media for the coliform count was prepared. 39 g violet red bile agar is mixed with 1 liter sterile distilled water. The mixture was boiled for dissolving completely and was sterilized in an autoclave at 121°C temperature (15 psi pressure for 15 min). The media was then cooled at 40°C and distributed to Petri dishes. *Peda* sample dilutions were taken in different Petri dishes and agar medium was added to each dish, these were then covered and labeled and kept in an incubator for 3 days at 25^0C and then coliform was calculated.

3.2.7 Sensory analysis of sugar-free herbal *peda*

Sugar-free herbal *Peda* was analyzed for different sensory characteristics like flavor, color and appearance, mouthfeel, body and texture, and overall acceptability. Sensory evaluation was performed by a panel of 10 semi-trained judges from the Department of Dairy Science and Food Technology, Banaras Hindu University, Varanasi (India). Sensory evaluation was performed at Room temperature (27^0c) and 60 % relative humidity.

9 – Point Hedonic scale rating (where, 1= dislike extremely, 9 = like extremely) **(Amerine *et al*., 1965**) was used for color, taste, sweetness, consistency and overall acceptability **(Shivkumar *et al*., 2007)**

3.2.8 Analysis of shelf life of sugar-free herbal *peda*

The effect of storage time and other factors on the acceptability of sugar-free herbal *Peda* was analyzed. Cardboard boxes were used for packaging and they were stored at room temperature. Acceptability was checked on the 0th, 3rd, 6th, 9th and 12th days after the sugar-free herbal *Peda* was prepared.

3.2.9 Statistical analysis of sugar-free herbal *Peda*

The mean values generated from the analyses of six samples of sugar-free herbal *Peda*, obtained in three replications were subjected to statistical analysis using completely randomized design (CRD) as per **Steel and Torrie (1980).**

Chapter IV

RESULTS AND DISCUSSION

4.1 Introduction

Traditional Indian dairy products and sweets are an important social, religious, cultural, medicinal, and economic component of Indian culture **(Bandyopadhyay *et al.*, 2006).** This largest and fastest-growing segment of the Indian dairy industry is estimated to be worth 75,000 crores **(Parekh, 2013).**

Due to its high content of milk solids, sugar, and other additives, *Peda* is a highly nutritious *khoa*-based sweet. *Peda* production in India surpasses that of other *khoa*-based sweets **(Mahadevan, 1991).**

4.2 Licorice

Licorice extracts and their main component, glycyrrhizin, are widely used in foods, tobacco products, traditional medicine, and herbal medicine. Licorice is approximately 50 times sweeter than sugar **(Meena *et al.*, 2010).**

The main component in *Glycyrrhiza* plants' root and stolon imparted a sweet flavor. Glycyrrhizin is a triterpene *saponin* of the *oleanane* class. This compound was a mixture of potassium-calcium-magnesium salts of *glycyrrhizic acid* that ranged from 2 to 25 percent **(Oblentseva, 1999)**

4.2.1 Licorice powder chemical composition

The chemical composition of licorice powder is mentioned in the table 4.1.

Table 4.1 Chemical composition of licorice powder

Parameters	Quantity (%)
Fat	5 - 6.35
Protein	1 - 3
Sugar	30 - 50
Ash	2 - 4
Moisture	1 – 5
Crude fiber	0 - 1

4.3 Date powder

Date powder is a natural sweetener with a sweet, fruity aroma and flavor. It has a strong aroma and a flavor that is somewhere between brown sugar and molasses. Proteins, minerals, and vitamins can be found in date powder. It is also a good source of iron and contains more iron and copper than refined sugar. It is a high-energy food that purifies the blood, regulates liver function, and keeps the body healthy. It is an important part of the diet as a type of sugar and is either consumed directly or used as a sweetening agent in sweet preparations **(Iftikhar *et al*., 2015)**

Dates have anti-inflammatory, anti-cancer, nephroprotective, and hemolytic properties. Dates have long been used in traditional medicine to treat or prevent colds, sore throats, fevers, abdominal problems, and reproductive system problems **(Raza *et al*., 2019)**

4.3.1 Date powder chemical composition

The chemical composition of date powder is mentioned in the table 4.2

Table 4.2 Chemical composition of date powder

Parameter	Quantity (%)
Fat	0.1-0.5
Protein	1-7
Sugar	44-88
Ash	1-2.5
Moisture	5-20
Crude Fibre	3-18
Polyphenol	3

Date acts as a natural sweetener and substitutes for sugar that has been chemically purified. As a result, research has been undertaken to achieve the objectives listed below.

1. To optimize the rate at which licorice and date powder are added in the preparation of sugar-free herbal *Peda*.
2. To assess the proximate composition, physicochemical, textural and sensory properties of sugar-free herbal *Peda*.
3. Determine the shelf life, cost and yield of sugar-free herbal *Peda*.

4.4 The effect of the rate of addition of licorice and date powder on compositional properties of sugar-free herbal *peda*

Moisture, fat, protein, ash, and total carbohydrates are the chemical components of sugar-free herbal *Peda*. They were examined to determine the extent to which they were present in sugar-free herbal *Peda*, as these are the properties that determine the product's composition, and thus its nutritional value and overall acceptability. As a result, the results obtained may be useful in providing some insight into the compositional aspects as well as their possible correlation with product acceptability and shelf life.

4.4.1 Moisture determination of sugar-free herbal *peda*

The addition of Licorice and date powder had a significant (P<0.05) effect on the moisture content of prepared sugar-free herbal *Peda*. The moisture content decreased significantly (P<0.05) as the rate of addition of Licorice and date powder increased. The average moisture content of the sugar-free herbal *Peda* in the experiment ranged from 23.89 (T6) to 25.66 (T1). The rate of addition of Licorice and date powder for the production of sugar-free herbal *Peda* was found to be significantly (P<0.05) different from the control sample (T0), which is 26.77 percent. The reduction in moisture content is due to the addition of date powder and licorice, which cause *khoa* to absorb water.

Tilekar (2007) discovered a similar closeness of moisture values in *Peda*, namely in the range of 9.22-22.38 percent, and **Dhobale (2016)** discovered a moisture range of 11.56-18.81 percent.

4.4.2 Fat determination of sugar-free herbal *peda*

According to Table 4.3, the mean fat content of the control *Peda* (T0) and experimental sugar-free herbal *Peda* samples, namely T1, T2, T3, T4, T5, and T6, was 18.19, 17.92, 17.58, 16.59, 16.27, 15.68, and 15.46 percent, respectively. The addition of Licorice and date powder to sugar-free herbal *Peda* was found to have a significant (P<0.05) effect. With the addition of Licorice and date powder, the fat content of the experimental samples (T2 to T6) decreased significantly (P<0.05). The average fat content of the sugar-free herbal *Peda* in the experiment ranged from 17.92 (T1) to 15.46 (T6) percent. However, the fat content of sample T6 (15.46) is significantly lower than that of T0 (18.19) percent.

The decrease in fat content is due to a decrease in the amount of *khoa*. Because *khoa* accounts for the majority of the fat content in *Peda*, date contributes a negligible proportion of the fat content.

Dhobale (2016) discovered similar fat content values in *Peda*, ranging from 14.78 to 17.04 percent. Also, **Tilekar (2007)** discovered that the fat content of Ahmednagar's market *Peda* was in the range of 10.90 - 21.60 percent, and **Londhe**

(2006) discovered that the fat content of brown *Peda* was in the range of 9.33-19.75 percent.

4.4.3 Protein determination of sugar-free herbal *peda*

Table 4.3 shows the protein content of sugar-free herbal *Peda* obtained during the study. The protein content of control *Peda* (T0) and sugar-free herbal *Peda* (T1, T2, T3, T4, T5, and T6) was 14.49, 14.38, 14.73, 13.91, 13.53, 13.50, and 13.20 percent, respectively. The addition of Licorice and date powder had a significant ($P<0.05$) effect on the protein content of the experimental sugar-free herbal *Peda*. The protein content increased significantly ($P<0.05$) as the rate of Licorice and date powder addition was reduced. The average protein content of the sugar-free herbal *Peda* in the experiments ranged from 14.38 (T1) to 13.20 (T6) percent.

The decrease in protein content value is due to a decrease in the amount of *khoa*. Because *khoa* accounts for the majority of the protein content in *Peda*. Licorice and dates have a lower proportion of protein content.

Londhe (2006) reported a similar value for the protein content of sugar-free herbal *Peda*, i.e. values ranging from 8.47 to 16.20 percent. **Tilekar (2007)** discovered that the protein content in Ahmednagar's market *Peda* ranged from 9.60 to 19.52 percent.

4.4.4 Ash determination of sugar-free herbal *peda*

The inorganic makeup of food is represented by the ash content of food. Minerals, metallic ions, and other food components are examples of inorganic constituents. The mineral content of a food is represented indirectly by its ash content **(Bakker and Elbersen, 2005).**

According to Table 4.3, the ash content of control *Peda* (T0) and experimental sugar-free herbal *Peda* (T1, T2, T3, T4, T5, and T6) was 2.31, 2.85, 3.36, 3.89, 3.37, 3.05, and 4.04 percent, respectively. The ash content increased significantly ($P<0.05$) as the rate of Licorice and date powder addition increased. The higher mineral content of date powder was responsible for the increase in ash content in sugar-free herbal *Peda*.

Table 4.3 Effect of rate of addition of Licorice and date powder on compositional properties of sugar-free herbal *Peda*

	Moisture %	Fat %	Protein %	Total carbohydrates %	Ash %
T0	$26.77^{b}\pm0.161$	$18.19^{f}\pm0.04$	$14.49^{d\pm}0.02$	$39.287^{a}\pm0.042$	$2.307^{a}\pm0.157$
T1	$25.66^{b}\pm0.367$	$17.92^{e\pm}0.05$	14.38^{d}	$37.66^{a\pm}0.371$	$2.853^{b}\pm0.052$
T2	$25.85^{b}\pm0.63$	$17.58^{d\pm}0.03$	$14.73^{e\pm}0.02$	$37.863^{a}\pm0.479$	$3.36^{b}\pm0.168$
T3	$23.99^{a}\pm0.248$	$16.59^{c\pm}0.1$	$13.91^{c\pm}0.06$	$38.447^{a}\pm0.177$	$3.893^{e}\pm0.071$
T4	$23.96^{a}\pm0.463$	$16.27^{b\pm}0.01$	$13.53^{b}\pm0.02$	$37.603^{a\pm}0.41$	$3.367^{d}\pm0.156$
T5	$23.91^{a}\pm0.457$	$15.68^{a\pm}0.11$	$13.50^{b}\pm0.03$	$38.34^{a\pm}0.173$	$3.047^{b}\pm0.075$
T6	$23.89^{a}\pm0.124$	$15.46^{g\pm}0.06$	$13.20^{a\pm}0.14$	$37.96^{a}\pm0.524$	$4.04^{f\pm}0.075$
C.D. (0.05)	1.191	0.204	0.178	N/A	0.355
SE(m)	0.389	0.066	0.058	0.387	0.116
SE(d)	0.55	0.094	0.082	0.547	0.164
C.V. %	2.709	0.0662	0.721	1.756	6.144

The average ash content of the sugar-free herbal *Peda* in the experiments ranged from 3.36 (T2) to 4.04 (T6) percent. The addition of Licorice and date powder to milk for making sugar-free herbal *Peda* increased the ash content of the experimental sugar-free herbal *Peda* significantly ($P<0.05$). The increased percentage of ash content is due to the addition of more date powder and licorice.

Londhe (2006) reported a similar ash content of sugar-free herbal *Peda*, with values ranging from 2.19 to 3.89 percent. **Dhobale (2016)** discovered similar ash content values in *Peda*, ranging from 2.19 to 2.68 percent.

4.4.5 Total carbohydrate determination of sugar-free herbal *peda*

Total carbohydrate in foods demonstrates the assimilation of both naturally occurring sugars in food and added sugar in food. Aside from nutrition, it is very important in terms of color and flavor. Carbohydrate is important in high-heat products because it contributes to *Maillard* browning **(Southgate, 1969).**

According to Table 4.3, the total carbohydrate content of control *Peda* (T0) and sugar-free herbal *Peda* (T1, T2, T3, T4, T5, and T6) were 39.28, 37.66, 37.86, 38.45, 37.60, 38.34, and 37.96 percent, respectively.

In the experimental sugar-free herbal *Peda*, the average total carbohydrate content ranged from 37.66 (T1) to 38.45 (T3) percent. The addition of Licorice and date powder to milk for the preparation of sugar-free herbal *Peda* resulted in a non-significant ($P>0.05$) decrease in the total carbohydrate content of the experimental samples.

Tilekar (2007) discovered a similar close aggregate value of total carbohydrate in the range of 45.32-60.44 percent in Ahmednagar's market *Peda*. **Dhobale (2016)** discovered similar values of the total carbohydrate content in *Peda*, ranging from 50.31 to 52.02 percent.

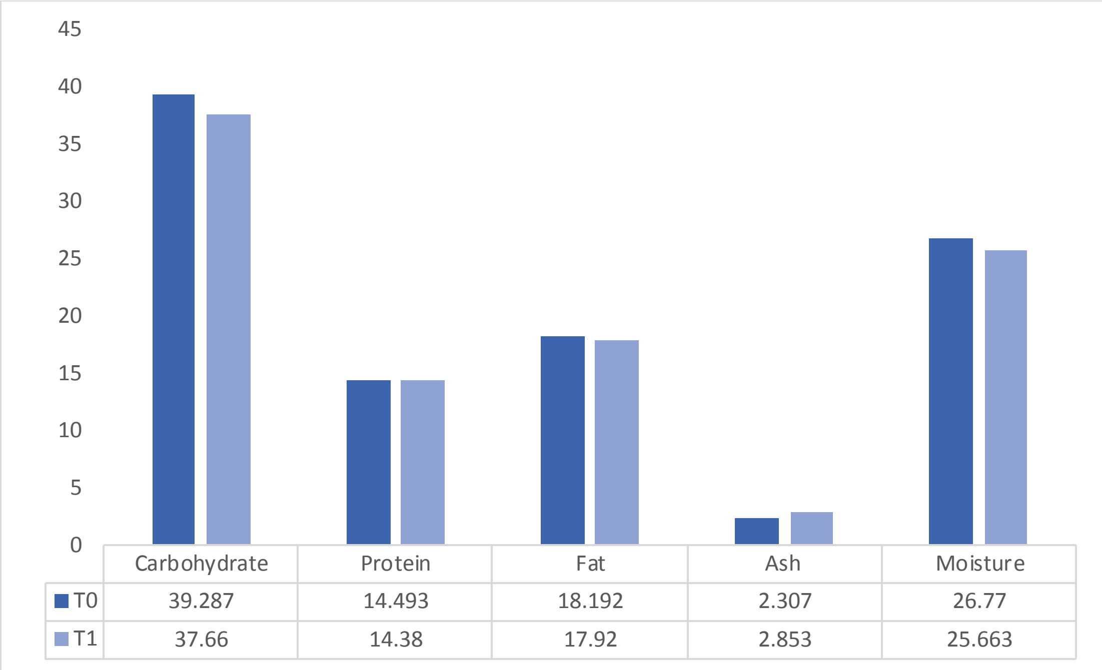

Fig 4.1 **Graphical representation of chemical composition of control (T0) and optimized (T1) sample of sugar-free herbal *peda*.**

4.5 The effect of the rate of Licorice and date powder addition on the texture profile of sugar-free herbal *Peda*

The sensory properties of the product, as well as its textural profile, are used to evaluate its quality. The instrumental texture assessment method aims to quantify textural characteristics objectively to the greatest degree.

4.5.1 The effect of the rate of addition of Licorice and date powder on the hardness of sugar-free herbal *Peda*

Hardness is the force required to achieve a given deformation in objective textural studies **(Larmond, 1976).** It is the highest point of peak in the first bite at a predetermined compression cycle on a two-bite distance force curve. A higher value denotes greater hardness.

Table 4.4 displays the data obtained for the hardness of sugar-free herbal *Peda*, as well as their statistical analysis. The average control *Peda* (T0) hardness value was 32.13 N. The average hardness of experimental sugar-free herbal *Peda* was

36.4, 39.77, 41.13, 41.24, 43.6, and 47.44 N, corresponding to T1, T2, T3, T4, T5, and T6, respectively.

The effect of Licorice and date powder addition on the hardness of experimental sugar-free herbal *Peda* was found to be significantly ($P<0.05$) increased in all sugar-free herbal *Peda* samples when the rate of addition of Licorice and date powder was increased. The average hardness value in the experimental sugar-free herbal *Peda* ranged from 36.4 (T2) N to 47.44N (T6).

The increased amount of date powder and licorice contributes to the increased hardness of sugar-free herbal *Peda*. According to **Patel *et al.* (1990),** the moisture content of *peda* has a direct relationship with hardness. **Patel (1990)** investigated the textural quality of *peda* samples collected from various cities in Gujarat. He stated that the hardness ranged from 2.086 to 17.822 N.

Londhe (2006) reported a similar result for the hardness of brown *Peda*, with values ranging from 78.16 to 93.22N. **Dhobale (2016)** discovered similar values for the hardness of peda, ranging from 9.30 to 91.75 N.

4.5.2 Effect of Licorice and date powder addition on the cohesiveness of sugar-free herbal *Peda*

Table 4.4 displays the data obtained for the cohesiveness of sugar-free herbal *Peda*, as well as their statistical analysis. The average value of control *Peda* (T0) cohesiveness was 0.274. The average cohesiveness of experimental sugar-free herbal *Peda* was 0.313, 0.348, 0.377, 0.358, 0.418, and 0.457, respectively, for T1, T2, T3, T4, T5, and T6. An increase in the rate of addition of licorice and date powder improves the product's cohesiveness. The average cohesiveness value in the experimental sugar-free herbal *Peda* ranged from 0.313 (T1) to 0.457. (T6).

The addition of Licorice and date powder to milk for sugar-free herbal *Peda* preparation increases the cohesiveness of the experimental sugar-free herbal *Peda* significantly ($P<0.05$).

Londhe (2006) reported a similar result for the cohesiveness of brown *Peda*, with values ranging from 0.152 to 0.171. **Dhobale (2016)** discovered similar values for cohesiveness, ranging from 0.05 to 0.109.

4.5.3 The effect of the rate of Licorice and date powder addition on the chewiness of sugar-free herbal *Peda*

The chewiness is a product of hardness, cohesiveness, and springiness and refers to the energy required to masticate food into a state suitable for swallowing **(Patel *et al*., 2011).**

Table 4.4 presents the data obtained for chewiness of sugar-free herbal *Peda*, as well as their statistical analysis. The average chewiness value of control *Peda* (T0) was 8.08 N mm. The average chewiness of the experimental sugar-free herbal *Peda* was 10.12, 10.57, 11.27, 11.20, 11.05, and 11.85 N-mm, corresponding to T1, T2, T3, T4, T5, and T6, respectively**.** The effect of Licorice and date powder addition on chewiness was found to be significantly (P<0.05) increased with the rate of addition of Licorice and date powder.

The average chewiness value in the experimental sugar-free herbal *Peda* ranged from 10.12 (T2) to 11.32. (T6). The addition of Licorice and date powder to milk for sugar-free herbal *Peda* preparation increases the chewiness of the experimental sugar-free herbal *Peda* significantly (P<0.05).

Londhe (2006) reported similar chewiness values for brown *Peda*, ranging from 2.15 to 3.53 N mm. **Dhobale (2016)** discovered similar chewiness values for *Peda*, ranging from 1.22 to 18.44 N mm.

4.5.4 Effect of Licorice and date powder addition on the adhesiveness of sugar-free herbal *Peda*

It is indicated by a negative peak following the first peak on the *Instron* two-bite force-distance curve. A higher force value indicates that the product is more adhesive **(Patel *et al*., 2011).** Adhesiveness, also known as stickiness, refers to how a food adheres to the palate during chewing.

Table 4.4 displays the data obtained for the adhesiveness of sugar-free herbal *Peda* as well as their statistical analysis. The average adhesiveness value of control *Peda* (T0) was 0.73 N-mm. The average adhesiveness values of experimental sugar-free herbal *Peda* were 0.84, 0.92, 1.15, 0.97, 1.20, and 1.26 N-mm, corresponding to T1, T2, T3, T4, T5, and T6, respectively.

The addition of Licorice and date powder to milk increased the adhesiveness of sugar-free herbal *Peda* significantly (P<0.05). The average adhesiveness value in sugar-free herbal *Peda* ranged from 0.84 (T2) N mm to 1.26 (T6) N mm.

The addition of Licorice and date powder to milk for making sugar-free herbal *Peda* increases the adhesiveness of the experimental sugar-free herbal *Peda* significantly (P<0.05).

Londhe (2006) reported that the adhesiveness values of sugar-free herbal *Peda* ranged from 45.08 to 149.22 N-mm. According to **Patel *et al.* (1993),** increasing the total solids in *khoa* decreased the adhesiveness. **Patel (1996)** determined that the adhesiveness of different *peda* samples drawn from different cities in Gujarat ranges from0.49 to 2.373 N-mm.

4.5.5 Effect of Licorice and date powder addition on the gumminess of sugar-free herbal *Peda*

Larmond (1976) defined gumminess as the amount of energy required to disintegrate a semi-solid food to the point where it is ready for swallowing. It is related to the primary parameters of hardness and cohesiveness and is calculated by multiplying these two values.

Table 4.4 displays the data obtained for gumminess, as well as their statistical analysis. The average gumminess of the control *Peda* (T0) was 8.567 N. The average gumminess values of experimental sugar-free herbal *Peda* were 11.38, 13.41, 15.81, 15.03, 18.21, and 21.57 N, corresponding to T1, T2, T3, T4, T5, and T6, respectively.

The addition of Licorice and date powder to milk increased the gumminess of sugar-free herbal *Peda* significantly (P<0.05). In the experimental sugar-free herbal

Peda, the average gumminess ranged from 11.38 (T1) N to 21.57 (T6) N. The addition of Licorice and date powder to milk for making sugar-free herbal *Peda* increases the gumminess of the experimental sugar-free herbal *Peda* significantly (P<0.05).

Miyani (1988) conducted a rheological study on Gujarat market *peda* samples and determined the average value of gumminess to be 31.38 kg. According to **Patel (1996),** the gumminess of *peda* samples collected from various cities in Gujarat ranged from 2.68 to 72.935. N. According to **Prasad *et al*. (2012),** the gumminess of *peda* samples collected in Varanasi ranged from 247.18 to 2037.90 g.

4.5.6 Effect of addition of Licorice and date powder on the springiness of sugar-free herbal *Peda*

Springiness is the height recovered by the sample during the force relaxation time between the first and second compression cycles **(Patel *et al*., 2011).**

Table 4.4 displays the data obtained for springiness, as well as their statistical analysis. The springiness of control *Peda* (T0) was 0.95 mm on average. The average springiness value of the experimental sugar-free herbal *Peda* was 0.87, 0.75, 0.73, 0.75, 0.60, and 0.52 mm, corresponding to T1, T2, T3, T4, T5, and T6, respectively.

The addition of Licorice and date powder to milk reduced the springiness of sugar-free herbal *Peda* significantly (P<0.05). Springiness ranged from 0.87 (T1) mm to 0.52 (T6) mm on average in experimental sugar-free herbal Peda. The addition of Licorice and date powder to milk for making sugar-free herbal *Peda* reduces the springiness of the experimental sugar-free herbal *Peda* significantly (P<0.05).

Miyani (1988) conducted a rheological study on Gujarat market *peda* samples and determined the average value of springiness to be 2.53 mm. He discovered that *peda* made from buffalo milk differed significantly from *peda* made from cow milk in terms of cohesiveness, gumminess, and springiness. According to **Patel (1996),** the springiness of *peda* samples collected from various cities in Gujarat ranged from 2.92 to 4.75 mm.

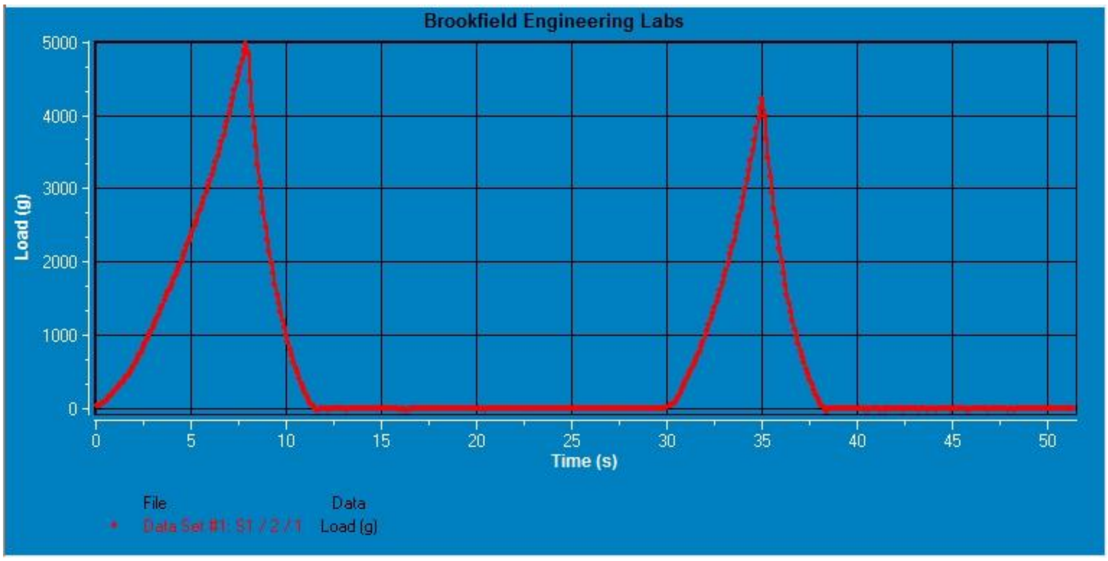

Fig. 4.2 **A representative Two-bite Force Distance Texture Profile curve of sugar-free herbal *Peda* optimized sample (T1)**

Table 4.4 Effect of addition of Licorice and date powder on texture profile of sugar-free herbal *Peda*

	Hardness (N)	Adhesiveness (N-mm)	Cohesiveness	Gumminess (N)	Springiness (mm)	Chewiness (N-mm)
T0	32.127 ^{a}±0.027	0.73 ^{a}±0.025	0.274 ^{a}±0.004	8.567^{a} ±0.19	0.952^{e} ±0.02	8.071^{a}±0.08
T1	36.4 ^{b}±0.025	0.837 ^{b}±0.02	0.313 ^{b}±0.003	11.38^{b}±0.03	0.876^{d}±0.01	10.1^{b}±0.07
T2	39.77 ^{c}±0.112	0.92 ^{c}±0.021	0.348 ^{c}±0.009	13.41^{c}±0.22	0.753^{c}±0.02	10.57 ^{c}±0.06
T3	41.13 ^{d}±0.049	1.153 ^{d}±0.024	0.377 ^{d}±0.001	15.81^{d}±0.14	0.733^{c} ±0.02	11.27^{d}±0.1
T4	41.243 ^{d}±0.024	0.97 ^{c}±0.032	0.358 ^{c}±0.001	15.03^{d}±0.16	0.751 ^{c}	11.2 ^{d}± 0.03
T5	43.6 ^{e}±0.019	1.2^{d}±0.012	0.418 ^{e}±0.004	18.21^{e}±0.1	0.597^{b}±0.01	11.05^{d}±0.04
T6	47.447 ^{f}±0.059	1.257^{e}±0.015	0.457 ^{f}±0.002	21.57^{f}±0.15	0.515^{a}±0.03	11.85^{e}±0.11
C.D. (0.05)	0.168	0.068	0.019	0.463	0.056	0.232
SE(m)	0.055	0.022	0.006	0.151	0.018	0.076
SE(d)	0.078	0.031	0.009	0.214	0.026	0.107
C.V. %	0.236	3.8	2.977	1.762	4.267	1.239

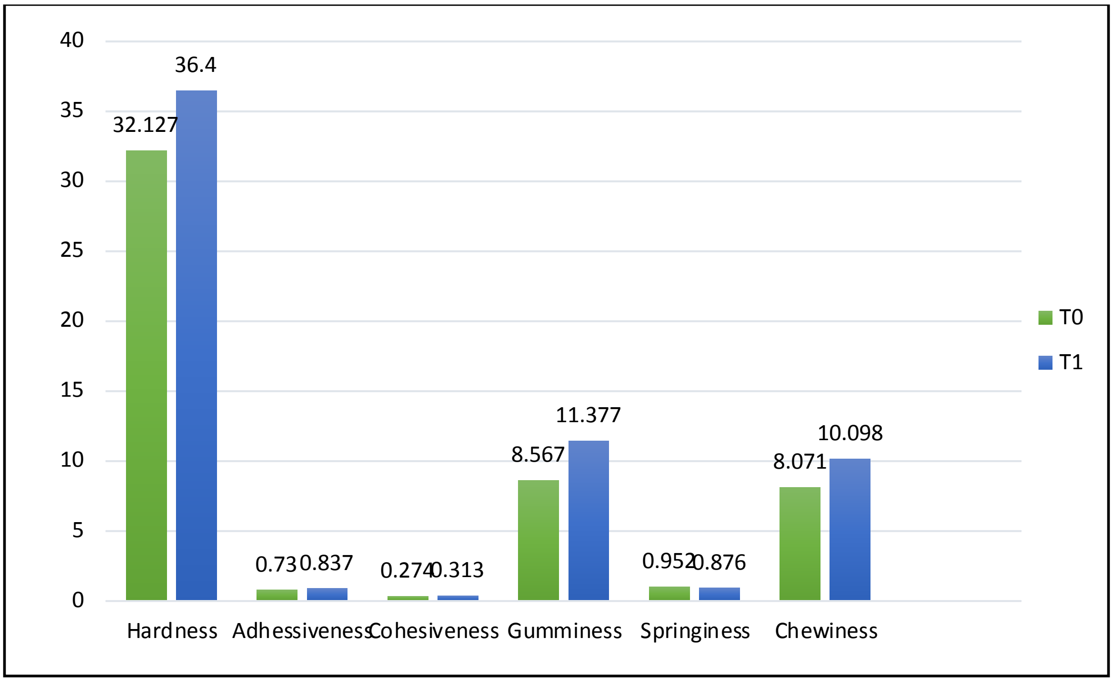

Fig 4.3 **Graphical representation of the difference in textural properties of control *peda (T0)* and optimized (T1) sugar-free herbal *peda***

4.6 Effect of rate of addition of licorice and date powder on the sensory score of sugar-free herbal *peda*

Sensory evaluation is the measurement and analysis of the quality of a food product based on information received from the five senses, namely sight, smell, taste, touch, and hearing. A panel of trained/ semi-trained judges evaluates the acceptability of any product based on the evaluation of sensory characteristics. Any product development process and sensory attributes are critical in determining product acceptability. Package, flavor, body and texture (B&T), color and appearance (C&A), and total score were chosen as sensory parameters to assess the quality of sugar-free herbal *Peda* as traditional Indian dairy products.

4.6.1 Effect of rate of addition of Licorice and date powder on color and appearance Score of sugar-free herbal *Peda*

Color is a common and basic sensory perception that appeals to the consumer for acceptance or rejection of a product. The product's color and appearance define visual perception, which in turn defines product quality. Table 4.5 shows the average score for color and appearance attributes of sugar-free herbal *Peda*. Control *Peda* (T0) had an average color and appearance score of 8.833. The color and appearance scores of the experimental sugar-free herbal *Peda* were 8.733, 7.67, 7, 7.67, 8, and 6.33, respectively, for T1, T2, T3, T4, T5, and T6. The rate of addition of licorice and date powder has little effect on the color and appearance score in T1 and T5, but it is significantly ($p<0.05$) reduced in T2, T3, T4, and T6.

Bhingardive (2013) reported a similar increasing trend in the color and appearance score of Licorice and date powder and wood apple added *Burfi*. **Dhobale (2016)** also reported a similar outcome.

Table 4.5 Effect of rate of addition of Licorice and date powder on the sensory score of sugar-free herbal *Peda*

	Color & appearance	Flavor	Sweetness	Body and texture	Overall Acceptability
T0	$8.833^{c}\pm0.167$	$8.667^{b}\pm0.333$	$8.567^{c\pm}0.296$	$8.667^{c}\pm0.333$	$8.5^{a}\pm0.289$
T1	$8.733^{c}\pm0.267$	$8.660^{b\pm}0.333$	$8.333^{c}\pm0.333$	$7.167^{a}\pm0.601$	$8.333^{a}\pm0.333$
T2	$7.667^{b}\pm0.333$	$7.5^{a}\pm0.289$	$7.5^{b}\pm0.333$	$7.333^{b}\pm0.882$	$7.833^{a}\pm0.441$
T3	$7^{a}\pm0.577$	$7.833^{a}\pm0.441$	$7.167^{a}\pm0.441$	$7.333^{b}\pm0.333$	$7.333^{a}\pm0.882$
T4	$7.667^{b}\pm0.333$	$7.667^{a}\pm0.333$	$7.667^{b}\pm0.333$	$7.333^{b}\pm0.577$	$7.667^{a}\pm0.333$
T5	$8^{c}\pm0.577$	$8^{b}\pm0.577$	$6.844^{a}\pm0.333$	$6.667^{a}\pm0.333$	$7.667^{a}\pm0.333$
T6	$6.333^{a}\pm0.333$	$6.667^{a}\pm0.333$	$6.333^{a}\pm0.333$	$6.344^{a}\pm0.333$	$6.333^{a}\pm0.333$
C.D. (0.05)	1.213	1.189	1.153	0.940	N/A
SE(m)	0.396	0.388	0.346	0.492	0.463
SE(d)	0.56	0.549	0.489	0.696	0.655
C.V. %	8.858	8.56	7.806	11.435	10.458

4.6.2 Effect of rate of addition of Licorice and date powder on flavor score of sugar-free herbal *Peda*

The flavor of traditional Indian dairy products is the most important criterion for evaluating their quality, which determines their acceptability. Table 4.5 shows the average score for the flavor attribute of sugar-free herbal *Peda*. Control *Peda* (T0) had an average flavor score of 8.67. T1, T2, T3, T4, T5, and T6 taste scores for experimental sugar-free herbal *Peda* were 8.66, 7.5, 7.83, 7.67, 8 and 6.67, respectively. The effect of adding licorice and date powder on flavor score was found to be significantly (P<0.05) different, with a T1 flavor score of 8.66 being significantly (P<0.05) higher than 21, T3, T4, T5, and T6. The rate of addition of licorice and date powder has little effect on the flavor score in T1 and T5, but it is significantly reduced in T2, T3, T4, and T6.

Bhingardive (2013) reported a similar increasing trend in the taste score of Licorice and date powder and wood apple added *Burfi* **Dhobale (2016)** also reported a similar outcome. According to **Reddy (1992),** an increase in fat content increases the flavor score of *peda*.

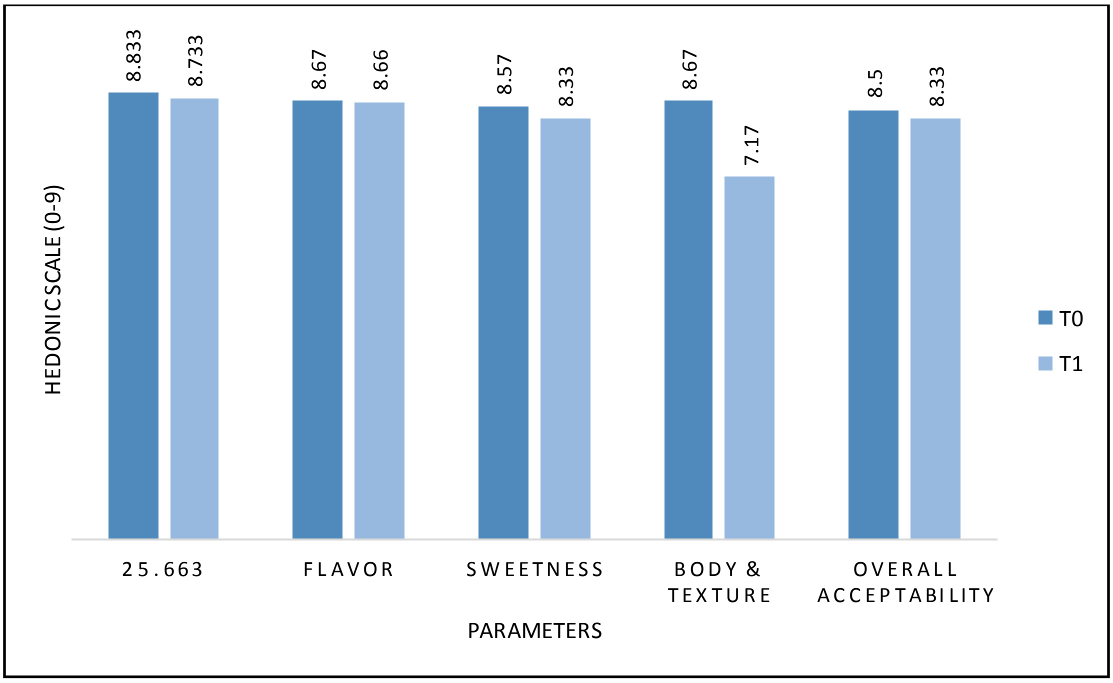

Fig. 4.4 **Graphical representation of sensory analysis of control and optimal sample of sugar-free herbal *Peda***

4.6.3 Effect of rate of addition of Licorice and date powder on body and texture score of sugar-free herbal *Peda*

The sugar-free herbal *Peda* body and texture are important factors in its acceptability. The ideal characteristics of the *Peda* are its distinct grain size, chewiness, and gumminess, which ultimately determine the product's acceptability. Body and texture describe the physical nature of the product in terms of smoothness, coarseness, and uniformity of settled. Table 4.5 shows the average score for the body and texture of sugar-free herbal *Peda*.

The control *Peda* (T0) had an average body and texture score of 8.67. The body and texture scores of the experimental sugar-free herbal *Peda* were 7.17, 7.33, 7.33, 7.33 6.67 and 6.34 respectively, for T1, T2, T3, T4, T5, and T6. The effect of adding Licorice and date powder on body and texture score was found to be significantly ($P<0.05$) different. T2, T3, and T4 all have the same 7.33 score. Sugar-free herbal *Peda* gains graininess and hardness from the addition of licorice and date powder. As a result, T5 and T6 receive lower scores than the control.

However, the addition of licorice and date powder has little effect on the body and texture of sugar-free herbal *Peda*.

Bhingardive (2013) reported a similar rising trend in the body and texture scores of *jaggery* and wood apple added *Burfi*. **Dhobale (2016)** also reported a similar output.

4.6.4 Effect of rate of addition of Licorice and date powder on sweetness score of sugar-free herbal *Peda*

Table 4.5 shows the average sweetness score of sugar-free herbal *Peda*. Control *Peda* (T0) had an average sweetness score of 8.57. The sweetness scores of the experimental sugar-free herbal *Peda* were 8.33, 7.50, 7.16, 7.67, 6.843, and 6.833, respectively, for T1, T2, T3, T4, T5, and T6. The sweetness score was not affected much by the addition of licorice and date powder. This experiment demonstrates that substituting licorice and date powder for sugar is effective. It has little effect on the sweetness of sugar-free herbal *peda* because date powder and licorice fulfill it. T1 had the highest sweetness score of 8.33.

The findings are consistent with those of **Ingale (2000),** who discovered that increasing the percentage of ash gourd pulp in *kalakand* was not well accepted by judges.

4.6.5 Effect of rate of addition of Licorice and date powder on overall acceptability score of sugar-free herbal *Peda*

Overall acceptability is a measure of a product's overall sensory quality, and it includes package, color and appearance, body and texture, and flavor characteristics that represent the product's overall performance in the minds of consumers. In this experiment, the overall acceptability score includes a package score of 5 out of 5. The overall acceptability score for sugar-free herbal *Peda* is shown in Table 4.5.

The overall acceptability score for Control *Peda* (T0) was 8.5. For T1, T2, T3, T4, T5, and T6, the overall acceptability score of the experimental brown *Peda* was 8.33, 7.833, 7.33, 7.66, 7.66, and 6.33, respectively. Licorice and date powder had no effect on the overall acceptability score ($P>0.05$). This experiment demonstrates the effectiveness of using licorice and date powder in the preparation of sugar-free herbal *peda*. T1 had the highest acceptance rate (8.33), while T6 had the lowest (6.33).

Bhingardive (2013) reported a similar rising trend in the Overall acceptability score of *jaggery* and wood apple, *Burfi* added. **Dhobale (2016)** reported a similar result.

4.7 Effect of storage on the microbiological quality of sugar-free herbal *peda*

Most milk products are highly perishable due to their microbiological quality. Because the shelf life of a product is solely determined by the growth of microorganisms in the product during storage, the microbiological quality of dairy products such as sugar-free herbal *Peda* becomes extremely valuable. The presence and growth of various microorganisms have a significant influence on most physicochemical changes in sugar-free herbal *Peda*, such as pH and acidity, which determine the fate of sugar-free herbal *Peda* during storage.

Considering these facts, sugar-free herbal *Peda* was tested for microbiological quality while stored at room temperature (37±1^{o}C). Tables and figures depict the microbiological situation (standard plate count, yeast and mold count). Regardless of storage temperature, all fresh and stored sugar-free herbal *Peda* samples had a 0 coliform count on 0 days as well as throughout storage, indicating hygienic manufacture.

4.7.1 Standard plate count of sugar-free herbal *peda*

The Standard Plate Count (SPC) is a collective listing of the product's overall microbiological quality after production and during storage. It provides an overall picture of the state of sugar-free herbal *Peda* in terms of microbiological quality during storage. Table 4.6 shows the average SPC values of sugar-free herbal *Peda* stored at ambient room temperature (37±1^{o}C).

The SPC of experimental sugar-free herbal *Peda* of treatment T1, at 37^{o}C was 1.09 *cfu*/g on the zero day and increased significantly ($p<0.05$) to 4.76 *cfu*/g on the 12th day. The SPC of T6 sample at 37^{o}C was 0.7 *cfu*/g on the first day and increased to 3.15 *cfu*/g on the 12th day. The SPC of both samples increased significantly ($P<0.05$) during ambient temperature storage. Treatments T3 and T6 have lower bacterial growth rates of 3.97 and 3.15 *cfu*/g on day 12 when compared to other treatments. This is due to the fact that it contains more licorice and date powder than others.

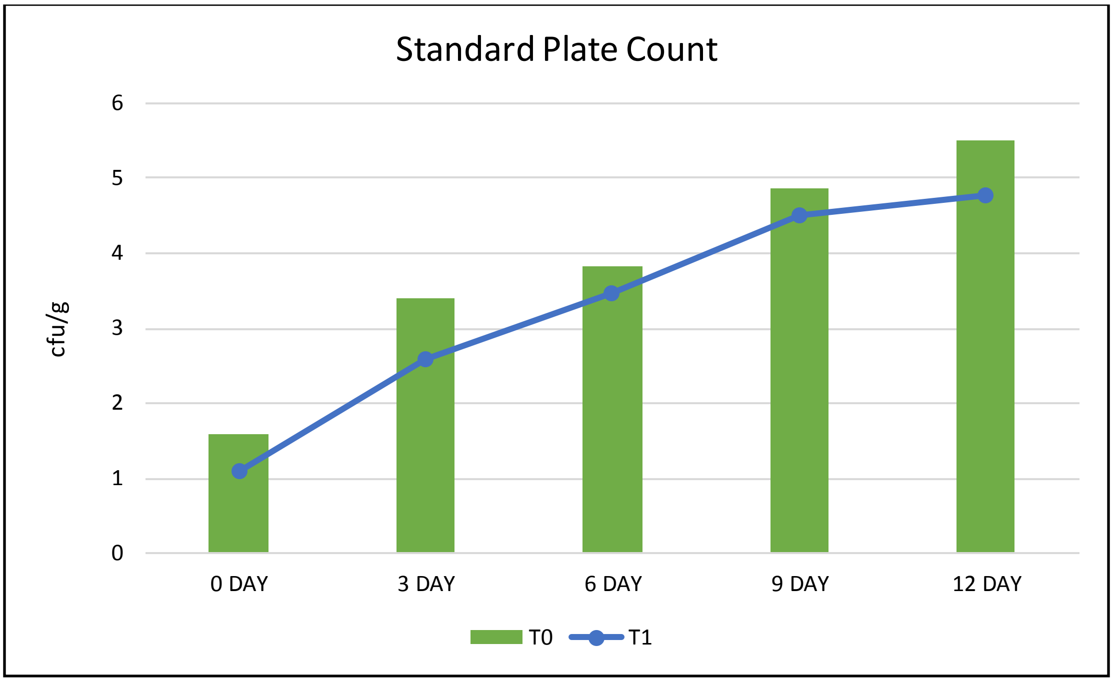

Fig 4.5 **Graphical representation of SPC between control (T0) and optimized (T1) sample of sugar-free herbal *peda***

Keerthi *et al.* (2017) discovered an increasing trend in SPC during *Peda* storage at 37±1°C. **Das (2004)** and **Londhe *et al.* (2012)** reported similar results for the storage of *Peda* at 30°C, respectively.

Table 4.6 Changes in SPC (*cfu*/g) during storage of sugar-free herbal *Peda* at ambient temperature (37±1°C)

	SPC (*cfu*/g)				
	0 DAY	**3 DAY**	**6 DAY**	**9 DAY**	**12 DAY**
T0	1.59^{e}±0.052	3.4^{d}±0.02	3.827^{c}±0.034	4.863^{e}±0.009	5.51^{e}±0.093
T1	1.09^{c}±0.038	2.58^{c}±0.023	3.48^{b}±0.021	4.507^{d}±0.124	4.76^{c}±0.047
T2	1.21^{d}±0.015	2.72^{c}±0.026	3.52^{b}±0.038	4.37^{c}±0.045	4.69^{c}±0.046
T3	0.83^{b}±0.013	1.1^{a}±0.072	2.193^{a}±0.047	3.59^{b}±0.084	3.967^{b}±0.041
T4	1.06^{c}±0.038	2.4^{b}±0.098	3.443^{b}±0.042	4.172^{c}±0.025	4.813^{d}±0.097
T5	1.08^{c}±0.02	2.53^{b}±0.022	3.463^{b}±0.007	4.283^{c}±0.041	4.613^{c}±0.027
T6	0.7^{a}±0.023	1.03^{a}±0.035	2.037^{a}±0.035	3.09^{a}±0.059	3.147^{a}±0.049
C.D.	0.097	0.156	0.105	0.201	0.191
SE (m)	0.032	0.051	0.034	0.066	0.062
SE (d)	0.045	0.072	0.049	0.093	0.088
C.V.	5.07	3.925	1.894	2.759	2.4

4.7.2 Yeast and mold count of sugar-free herbal *peda*

The yeast and mold count of sugar-free herbal *Peda* during storage at room temperature increased statically with the storage period. The average values of yeast and mold count of sugar-free herbal *peda* (*cfu/*g) performed in triplicate are shown here. Table 4.7 shows the average values for yeast and mold count of sugar-free herbal *Peda* stored at room temperature (37±1°C). The yeast and mold count of experimental sugar-free herbal *Peda* at T0 was absent on the first day and increased to 120.11 *cfu*/g on the 12th. The yeast and mold count in samples at room temperature 37±1°C increased significantly ($p<0.05$).

The BIS standard for yeast and mold counts for *peda* is 50 *cfu*/g. According to the data in table 4.7, the shelf life of experimental *peda* is 8-9 days as opposed to 7-8 days for normal *peda*. According to the results of this experiment, the shelf life of sugar-free herbal *peda* is increased by 1-2 days. The shelf life of treatment T3 and T6 with a higher percentage of licorice is found to be 9- 10 days.

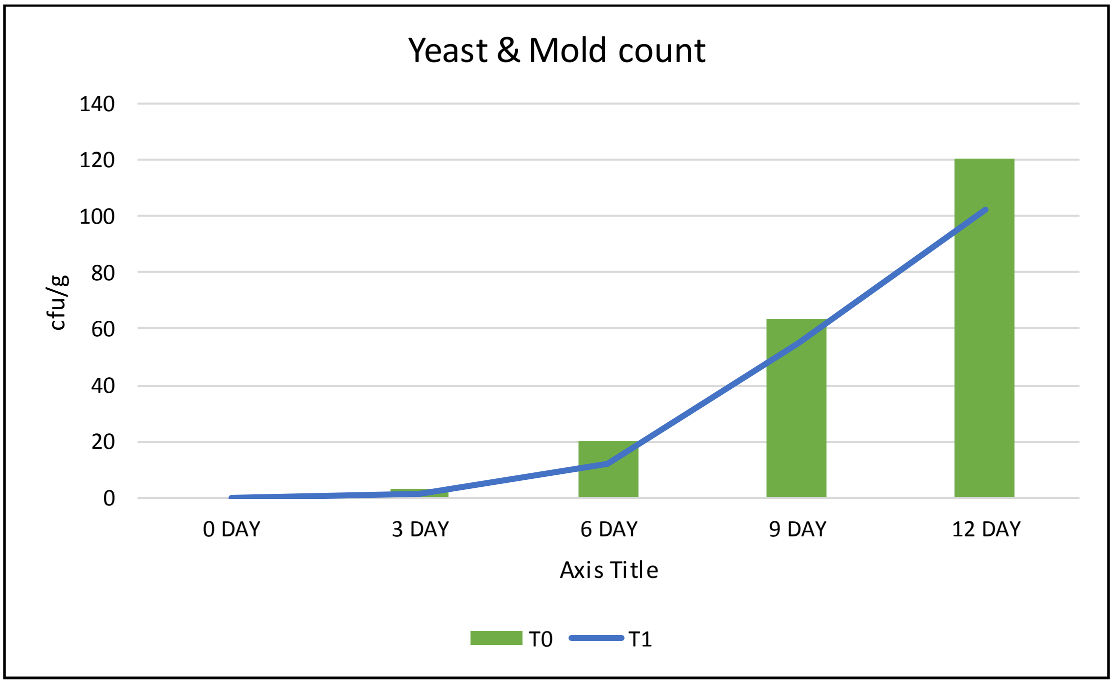

Fig 4.6 **Graphical representation of SPC between control (T0) and optimized (T1) sample of sugar-free herbal *peda***

Keerthi *et al*. (2017) discovered a rising pattern in yeast and mold counts during *Peda* stored at 37±1°C. Das (2004) and **Londhe *et al*. (2012)** reported similar results for storage of *Peda* and sugar-free herbal *Peda* at 30°C, respectively.

Table 4.7 Changes in SPC (*cfu*/g) during storage of sugar-free herbal *Peda* at ambient temperature (37±1°C)

	YEAST & MOLD (*cfu*/g)				
	0 DAY	**3 DAY**	**6 DAY**	**9 DAY**	**12 DAY**
T0	0	3.24^{c}±0.046	20.27^{e}±0.033	63.25^{g}±0.041	120.11^{f}±0.068
T1	0	1.12^{b}±0.121	12.33^{d}±0.042	54.94^{f}±0.047	102.18^{e}±0.045
T2	0	1.04^{b}±0.042	12.007^{c}±0.017	54.57^{e}±0.102	101.95^{d}±0.046
T3	0	0	5.09^{b}±0.028	40.27^{b}±0.031	92.56^{b}±0.071
T4	0	0.91^{a}±0.018	11.95^{d}±0.051	49.97^{d}±0.043	100.15^{c}±0.093
T5	0	0.84^{a}±0.026	11.62^{c}±0.03	48.11^{c}±0.059	100.1^{c}±0.04
T6	0	0	4.003^{a}±0.015	38.31^{a}±0.099	90.073^{a}±0.041
C.D.	-	0.156	0.105	0.201	0.191
SE (m)	-	0.051	0.034	0.066	0.062
SE (d)	-	0.072	0.049	0.093	0.088
C.V.	-	3.925	1.894	2.759	2.4

4.7.3 Coliform count of sugar-free herbal *peda*

Sugar-free herbal *Peda* samples stored at ambient temperature were found to be free from coliform at the end of 12 days of storage study.

4.8 Antioxidant activity of sugar-free herbal *peda*

In ethanol, DPPH in oxidized form produces a deep violet color. An antioxidant compound donates an electron to DPPH, causing it to be reduced and its color changes from deep violet to yellow **(Shirazi *et al.*, 2014).** Table 4.6 displays the data obtained for antioxidant activity of sugar-free herbal *Peda,* as well as their statistical analysis. The average antioxidant activity of control *Peda* (T0) was 5.058 percent. The average antioxidant activity of experimental sugar-free herbal *Peda* was 43.88, 47.66, 67.18, 52.18, 55.48 and 73.3 percent for T1, T2, T3, T4, T5, and T6, respectively. The effect of Licorice and date powder addition on antioxidant activity was found to be significantly (P<0.05) higher as the rate of addition of Licorice and date powder increased.

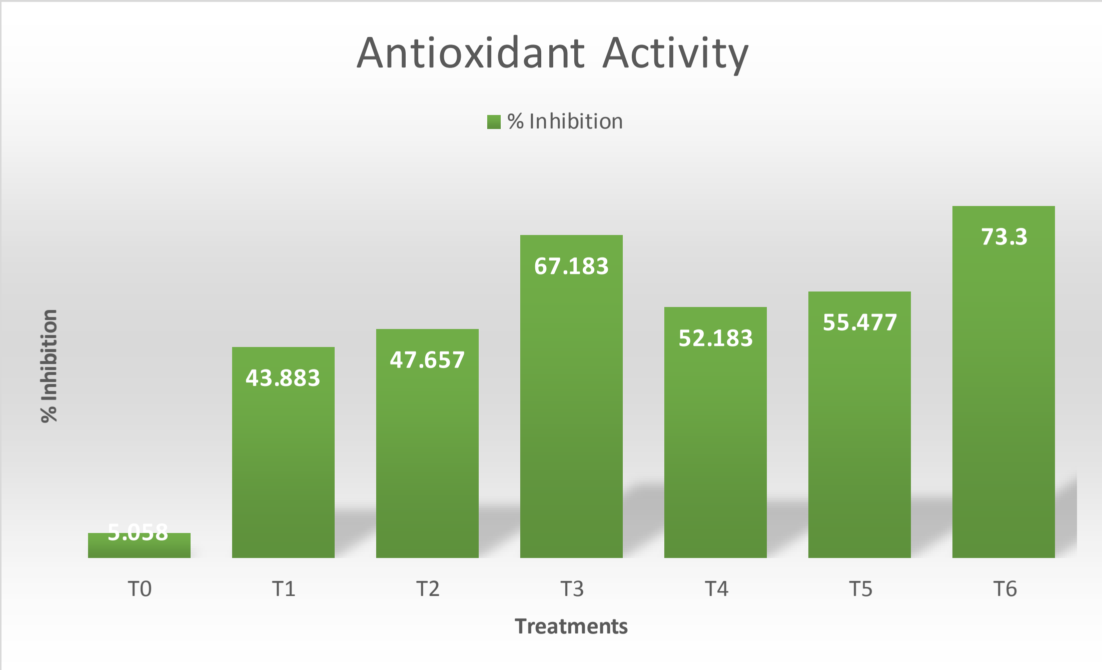

Fig: 4.7 Graphical representation of antioxidant activity of sugar-free herbal *Peda*

The average antioxidant activity in sugar-free herbal *Peda* ranged from 43.88 (T1) to 73.3 percent (T6). The inclusion of Licorice and date powder in milk for the preparation of sugar-free herbal *Peda* significantly (P<0.05) increases the antioxidant activity of the experimental sugar-free herbal *Peda*.

Table 4.6 Antioxidant activity of sugar-free herbal *Peda*

Treatments	Formulation per 100 gm (*khoa*: date powder: Licorice)	Absorbance (nm)	% Inhibition
T0	70:30	0.32[a]±0.02	5.058 [a]±0.03
T1	65:30:5	0.42 [a]±0.24	43.88 [b]±0.02
T2	60:36:4	0.19 [a]	47.66 [c]±1.29
T3	60:30:10	0.11 [a]	67.18 [d]±0.54
T4	55:40:5	0.16 [a]	52.18 [e]±0.06
T5	50:45:5	0.14 [a]	55.48 [f]±0.28
T6	45:45:10	0.1 [a]±0.01	73.3 [g]±0.03
C.D. (0.05)		N/A	1.649
SE(m)		0.09	0.539
SE(d)		0.13	0.762
C.V. %		75.4	1.894

The antioxidant activity of sugar-free herbal *Peda* has increased due to the addition of licorice and date powder. Because licorice and date powder contains a high concentration of different antioxidant compounds, the percent inhibition activity increases with the addition of licorice and date powder.

The antioxidant capacity of the extract was determined by DPPH assay to be 56.23±3.56 & 11.67±1.18 for black rice and control extracts, respectively. It can be concluded that Black Rice has significantly higher antioxidant capacity than White Rice. These findings agreed with those of **Sampong *et al.* (2011)** and **Walter *et al.* (2013),** who found that the DPPH value ranged from 59.02 to 75.52 percent for black rice varieties. White rice had the lowest level of antioxidant activity. It could be due to a decrease in polyphenol content, as higher concentrations of total soluble phenolic content were associated with lower antioxidant activity **(Walter *et al*., 2013).**

4.9 Yield estimation of sugar-free herbal *Peda*

The yield was correlated to the total solids content of the product. In terms of product structure and the entire economy, it is crucial. Sweets manufacturing and management may both benefit from yield assessment. It is important for preproduction planning since it offers an estimate of raw material requirements. As a result, food product yield is important from a manufacturing aspect **(Emmons *et al*., 1990).**

The yield of control *Peda* (T0) and experimental sugar-free herbal *Peda* (T1, T2, T3, T4, T5, and T6) were 23.15, 24.02, 24.86, 24.83, 25, 25.74, and 25.94 percent, respectively, according to the experiment.

As the rate of licorice and date powder addition was raised, the production of sugar-free herbal Peda increased significantly ($P<0.05$). In sugar-free herbal *Peda* trials, the average yield varied from 23.15 (T1) to 25.94 (T6) percent. The addition of licorice and date powder to khoa for the manufacturing of sugar-free herbal *Peda* significantly increased the yield of experimental sugar-free herbal *Peda* ($P<0.05$).

There is no published research comparing the effect of licorice and date powder addition on the yield of *Peda* or similar products.

4.10 Cost estimation of sugar-free herbal *peda*

The price of a product is a key factor in its commercialization and effective marketing. The cost of any product is determined by a variety of variable elements such as the cost of raw materials, the cost of processing and packaging, and so on. An attempt was made to estimate the cost of sugar-free herbal *Peda* that has been optimized. 3 kg milk (Standardized milk), 300 g date powder, and 50 g licorice powder were used to make 1 kg of optimal sugar-free herbal *Peda*. Thus, the overall production cost of optimized sugar-free herbal *Peda* was determined to be 265 Rs. per kg, which was comparable to the cost of the control *Peda*, which was 256 Rs. per kg.

The experimental investigation indicated that the best acceptable grade sugar-free herbal *Peda* was created by adding licorice and date powder by substituting 30% sugar in milk (w/w) with 30 g date powder and 5 g licorice.

Table 4.7 Estimated production cost of 1.0 kg of control *peda* and sugar-free herbal *Peda*

Ingredients	Rate Rs/Kg	*Peda* control (T0)		*Peda* optimized (T1)	
		Quantity	Rs.	Quantity	Rs.
Milk	60.00	4 kg	240.00	3 kg	180.00
Sugar	50.00	320 g	16.00	-	-
Date powder	200.00	-	-	300 g	60.00
Licorice powder	500.00	-	-	50 g	25.00
Rate Rs/Kg	-	1.00 kg	256.00	1.00 kg	265.00

SUMMARY AND CONCLUSION

➢ Summary

Traditional Indian dairy products are an integral part of Indian heritage and culture. These products have been developed over a long period with the culinary skills of housewife's and *halwais* and possess great social, religious, cultural, medicinal and economic importance. The production of many of the traditional foods is cumbersome and time consuming. Attempts have been made to produce and present products that is high in the nutritional quality.

The date palm (Phoenix dactylifera L.) fruit is sweet and edible. Dates are low in fat and therefore suitable for heart patients. Dates have a high carbohydrate content (70%) that is dominated by sugars. Dates have a low-fat content (0.2 to 0.5 percent), a high protein content (2.3 to 5.6 percent), vitamins, and are a good source of dietary fiber (6.4 to 11.5 percent). Dates are high in phenolic compounds and antioxidants, as well as minerals such as selenium, copper, potassium, and magnesium.

Herbs have medicinal properties and have been used since ancient times. Licorice is sweet wood, and it was one of the most widely used herbs in ancient medicine, both as a medicine and as a flavoring herb. It has been used to treat respiratory, gastrointestinal, cardiovascular, eye, and skin disorders as an anti-allergic, demulcent, emollient, and fungicide. As a result, one of the alternatives is to use dairy products.

Earlier attempts were made to use different ingredients in manufacturing of the *Peda* but used sugar as a sweetener in it. The objective of the recent study was to evaluate the utilization of date powder and licorice as natural sweetener for replacement of sugar in developing value-added sugar-free herbal *Peda*. The current work was focused on the following broad objectives:

Objectives

1. Process optimization for sugar-free herbal *Peda* preparation.
2. Identification of the physicochemical and sensory properties of sugar-free herbal *Peda*.
3. Determination of rheological and microbiological properties of sugar-free herbal *Peda*.
4. Calculate the yield, cost and shelf life of sugar-free herbal *Peda*.

Combination of three batches of sugar-free herbal *Peda* was prepared in different proportions on weight basis along with control (*Peda* without date powder and licorice addition).

Khoa: date powder: licorice were mixed in proportions of 65:30:5, 60:36:4, 60:30:10, 55:40:5, 50:45:5 and 45:45:10 for T1, T2, T3, T4, T5 and T6, respectively. *Khoa* was heated with vigorous working after which licorice and date powder was mixed into it. The mixture was spread on a stainless-steel tray and cooled to set at an ambient temperature. Then it was cut into pieces of uniform size and shape. Total 6 treatments were replicated 3 times. All the experimental samples were analyzed by completely randomized design (CRD) throughout this study. The effect of addition of licorice and date powder in *khoa* on weight basis on sugar-free herbal *Peda* has been summarized here under.

5.1 The effect of the rate of addition of licorice and date powder on compositional properties of sugar-free herbal *peda*

5.1.1 Moisture

The average moisture content of the sugar-free herbal *Peda* in the experiment ranged from 23.89 (T6) to 25.66 (T1). The moisture content decreased significantly ($P<0.05$) as the rate of addition of Licorice and date powder increased.

5.1.2 Fat

The average fat content of the sugar-free herbal *Peda* in the experiment ranged from 17.92 (T1) to 15.46 (T6) percent. With the addition of Licorice and date powder, the fat content of the experimental samples (T1 to T6) decreased significantly ($P<0.05$).

5.1.3 Protein

The average protein content of the sugar-free herbal *Peda* in the experiments ranged from 14.38 (T1) to 13.20 (T6) percent. The protein content increased significantly ($P<0.05$) as the rate of Licorice and date powder addition was reduced.

5.1.4 Ash

The average ash content of the sugar-free herbal *Peda* in the experiments ranged from 3.36 (T2) to 4.04 (T6) percent. The addition of Licorice and date powder to *khoa* for making sugar-free herbal *Peda* increased the ash content of the experimental sugar-free herbal *Peda* significantly ($P<0.05$).

5.1.5 Total carbohydrate

In the experimental sugar-free herbal *Peda*, the average total carbohydrate content ranged from 37.66 (T1) to 38.45 (T3) percent. The addition of Licorice and date powder to milk for the preparation of sugar-free herbal *Peda* resulted in a non-significant ($P>0.05$) decrease in the total carbohydrate content of the experimental samples.

5.2 The effect of the rate of Licorice and date powder addition on the texture profile of sugar-free herbal *Peda*

5.2.1 Hardness

The average hardness value in the experimental sugar-free herbal *Peda* ranged from 36.4 (T2) N to 47.44N (T6). The effect of Licorice and date powder addition on the hardness of experimental sugar-free herbal *Peda* was found to be significantly

(P<0.05) increased in all sugar-free herbal *Peda* samples when the rate of addition of Licorice and date powder was increased.

5.2.2 Cohesiveness

The average cohesiveness value in the experimental sugar-free herbal *Peda* ranged from 0.313 (T1) to 0.457. (T6). The addition of Licorice and date powder to milk for sugar-free herbal *Peda* preparation increases the cohesiveness of the experimental sugar-free herbal *Peda* significantly (P<0.05).

5.2.3 Adhesiveness

The average adhesiveness value in sugar-free herbal *Peda* ranged from 0.84 (T2) N mm to 1.26 (T6) N mm. The addition of Licorice and date powder to milk increased the adhesiveness of sugar-free herbal *Peda* significantly (P<0.05).

5.2.4 Chewiness

The average chewiness value in the experimental sugar-free herbal *Peda* ranged from 10.12 (T2) to 11.32. (T6). The addition of Licorice and date powder to milk for sugar-free herbal *Peda* preparation increases the chewiness of the experimental sugar-free herbal *Peda* significantly (P<0.05).

5.2.5 Gumminess

In the experimental sugar-free herbal *Peda*, the average gumminess ranged from 11.38 (T1) N to 21.57 (T6) N. The addition of Licorice and date powder to milk for making sugar-free herbal *Peda* increases the gumminess of the experimental sugar-free herbal *Peda* significantly (P<0.05).

5.2.6 Springiness

Springiness ranged from 0.87 (T1) mm to 0.52 (T6) mm on average in experimental sugar-free herbal *Peda*. The addition of Licorice and date powder to milk for making sugar-free herbal *Peda* reduces the springiness of the experimental sugar-free herbal *Peda* significantly ($P<0.05$).

5.3 Effect of rate of addition of licorice and date powder on the sensory score of sugar-free herbal *peda*

The sugar-free herbal *Peda* samples were evaluated by semi-trained panel using the score card based on 9- point hedonic scale.

5.3.1 Color and appearance

The average color and appearance scores of the experimental sugar-free herbal *Peda* were 8.733, 7.67, 7, 7.67, 8, and 6.33, respectively, for T1, T2, T3, T4, T5, and T6. The rate of addition of licorice and date powder has little effect on the color and appearance score in T1 and T5, but it is significantly ($p<0.05$) reduced in T2, T3, T4, and T6.

5.3.2 Body and texture

The control *Peda* (T0) had an average body and texture score of 8.67. The average body and texture scores of the experimental sugar-free herbal *Peda* varied from 7.17(T1) to 6.34 (T6). The effect of adding Licorice and date powder on body and texture score was found to be significantly ($P<0.05$) different.

5.3.3 Flavor

The average flavor score of experimental sugar-free herbal peda varied from 8.66 (T1) to 6.67 (T6). The effect of adding licorice and date powder on flavor score was found to be significantly ($P<0.05$) different, with a T1 flavor score of 8.66 being significantly ($P<0.05$) higher than T2, T3, T4, T5, and T6. The rate of addition of licorice and date powder has little effect on the flavor score in T1 and T5, but it is significantly reduced in T2, T3, T4, and T6.

5.3.4 Sweetness

The average sweetness score of the experimental sugar-free herbal *Peda* varied from 8.33 (T1) to 6.833 (T6). The sweetness score was not affected much by the addition of licorice and date powder. The effect of adding licorice and date powder on sweetness score was found to be significantly ($P<0.05$) increased.

5.3.5 Overall acceptability

The average sweetness score of the experimental sugar-free herbal *Peda* varied from 8.33 (T1) to 6.33 (T6). The overall acceptability was not affected much by the addition of licorice and date powder. The effect of adding licorice and date powder on overall acceptability score was found to be non-significantly ($P>0.05$).

5.4 Effect of storage on the microbiological quality of sugar-free herbal *peda*

The SPC of experimental sugar-free herbal *Peda* of treatment T1, at 37^{o}C was 1.09 *cfu*/g on the zero day and increased significantly ($p<0.05$) to 4.76 *cfu*/g on the 12th day. The SPC of T6 sample at 37^{o}C was 0.7 *cfu*/g on the first day and increased to 3.15 *cfu*/g on the 12th day. The SPC of both samples increased significantly ($P<0.05$) during ambient temperature storage. Treatments T3 and T6 have lower bacterial growth rates of 3.97 and 3.15 *cfu*/g on day 12 when compared to other treatments. This is due to the fact that it contains more licorice and date powder than others.

The yeast and mold count of experimental sugar-free herbal *Peda* of T0 was absent on the first day and increased to 120.11 *cfu*/g on the 12th. The yeast and mold count in samples at room temperature 37±1^{o}C increased significantly ($p<0.05$).

Sugar-free herbal *Peda* samples stored at ambient temperature were found to be free from coliform at the end of 12 days of storage study.

5.5 Antioxidant activity of sugar-free herbal *peda*

The average antioxidant activity in sugar-free herbal *Peda* ranged from 43.88 (T1) to 73.3 percent (T6). The inclusion of Licorice and date powder in milk for the preparation of sugar-free herbal *Peda* significantly ($P<0.05$) increases the antioxidant activity of the experimental sugar-free herbal *Peda*.

5.6 Yield estimation of sugar-free herbal *Peda*

The average yield in sugar-free herbal *Peda* experiments ranged from 24.57 (T1) to 25.98 (T6) percent. The addition of licorice and date powder to *khoa* for sugar-free herbal *Peda* production increased the yield of experimental sugar-free herbal *Peda* non-significantly ($P>0.05$).

CONCLUSION

The experimental investigation indicated that the best acceptable grade sugar-free herbal *Peda* was created by adding licorice and date powder by substituting 30% sugar in milk (w/w) with 30 g date powder and 5 g licorice.

The product obtained had a shelf-life up to 8-9 days at ambient temperature ($37\pm1^{o}C$). The cost of raw material for sugar-free herbal *Peda* was ₹ 265.00 per kg.

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APPENDICES

Appendix-I

Sensory Evaluation Card

DEPARTMENT OF DAIRY SCIENCE AND FOOD TECHNOLOGY

BHU, VARANASI

PRODUCT- SUGAR-FREE HERBAL *PEDA*

DATE:

TIME:

NAME OF THE PANELIST:

Instruction: Given below is the sample of **"SUGAR-FREE HERBAL *PEDA*"**. You are requested to judge the sample on the 9 points hedonic scale for the parameters listed below:

Hedonic Scale	**Score**
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Sample	Color & appearance	Flavor	Sweetness	Body and texture	Overall acceptability
S1					
S2					
S3					
S4					
S5					
S6					

Remark Signature

Appendix-II

Color and appearance score of sugar-free herbal *peda*

Color and appearance is the 1st step to acceptance or rejection of any product. The color of sugar-free herbal *Peda* samples was slightly greenish-yellow as licorice and date powder was added to it and it was acceptable.

	S1	S2	S3	S4	S5	S6
T1	7	8	6.5	8.5	7	7
T2	8	7	7	8	8	8
T3	8	8	6	6	6	6
T4	7	9	6	8	7	6
T5	8	9	7	8	8	7
T6	8	6	8	7	8	9
T7	7	8	7	6	8	8
T8	7	6	8	7	7	8
MEAN	**7.50**	**7.63**	**6.93**	**7.31**	**7.38**	**7.37**

The color and appearance scores varied from 7.00 to 7.63. The minimum color and appearance score was obtained in S1, while the maximum color and appearance score was observed in S2.

Appendix-III

Flavor score of sugar-free herbal *peda*

Flavor is one of the important parameters in sensory analysis. The acceptability of the product depends upon the taste.

	S1	S2	S3	S4	S5	S6
T1	7.5	8	7	8	8	7
T2	7	8	8	8	9	7
T3	7	8	6	7	7	7
T4	8	7	7	7	8	7
T5	9	9	8	9	9	8
T6	7	8	7	7	7	8
T7	8	7	6	8	7	7
T8	9	7	6	8	7	6
MEAN	**7.81**	**7.75**	**6.87**	**7.75**	**7.75**	**7.13**

From the table, it can be inferred that the flavor score for Sugar-free herbal *Peda* was highest in S1 (7.81) and the lowest value was for S3 (6.87).

Appendix-IV

Sweetness score of sugar-free herbal *peda*

In *Peda*, sweetness is regarded as a component of mouthfeel. *Peda* has a poor mouthfeel due to its lack of or excess sweetness. This aspect of *Peda* is important in milk *Peda*, but in brown *Peda*, sweetness is covered by its caramel flavor.

	S1	S2	S3	S4	S5	S6
T1	8	8	6.5	8.5	8	7
T2	8	8	9	8	9	7
T3	8	8	7	7	7	7
T4	8	7	7	8	7	7
T5	9	9	9	8	9	9
T6	8	9	7	7	6	8
T7	8	7	8	6	7	8
T8	9	7	8	6	9	7
MEAN	**8.25**	**7.87**	**7.67**	**7.31**	**7.75**	**7.5**

The sweetness score varied from 6.88 to 87.87. The minimum sweetness score was obtained in S1, while the maximum color and appearance score was observed in S2.

Appendix-V

Body and texture score of sugar-free herbal *peda*

The sugar-free hrbal *peda* body and texture are important factors in its acceptability. The ideal characteristics of the *Peda* are its distinct grain size, chewiness, and gumminess, which ultimately determine the product's acceptability. Body and texture describe the physical nature of the product in terms of smoothness, coarseness, and uniformity of settled.

	S1	S2	S3	S4	S5	S6
T1	7	8	6.5	8.5	8	7
T2	9	7	9	9	8	7
T3	7	8	7	7	7	7
T4	7	8	7	7	7	7
T5	9	9	9	9	8	8
T6	8	8	8	7	6	7
T7	7	6	8	8	8	7
T8	7	8	8	8	7	6
MEAN	**7.63**	**7.75**	**7.81**	**7.94**	**7.37**	**7**

From the table it can be inferred that the consistency score of Sugar-free herbal *Peda* was highest in S4 (7.94) and the lowest value was for S6 (7).

Appendix-VI

Overall acceptability score of sugar-free herbal *peda*

Overall acceptability is the sum of all of the preceding factors. It indicated the likelihood of consumer acceptance of the product. The highest overall acceptability indicates that the product was preferred by many consumers over competing products.

	S1	S2	S3	S4	S5	S6
T1	8	8	6.5	8.5	8	7
T2	9	8	8.5	8	9	7
T3	8	8	6	7	7	7
T4	7	8	7	7	7	7
T5	9	9	8	8	8	8
T6	8	6	9	7	7	6
T7	8	7	8	8	7	6
T8	7	8	8	8	9	7
MEAN	**7.88**	**7.75**	**7.63**	**7.69**	**7.75**	**6.87**

The overall acceptability was highest in case of S4 (7.94) and lowest in case of S5 (6.87).

Appendix-VII

Comparative study for sensory attributes of sugar-free herbal *Peda*

The mean scores for all of the samples ranged from "like moderately" to "like very much." No variant fell into the dislike or neither like nor dislike categories.

Color & appearance and Flavor were the sensory parameters that showed a significant difference and were affecting the sensory scores of the product and consumer acceptability, and thus these parameters were used for product optimization.

Sample no.	Mean value for color and appearance	Mean value for flavor	Mean value for sweetness	Mean value for body & texture	Mean value for overall acceptability
S1	7.50	7.81	8.28	7.63	7.88
S2	7.63	7.75	7.87	7.75	7.75
S3	6.93	6.87	7.67	7.81	7.63
S4	7.31	7.75	7.31	7.94	7.69
S5	7.38	7.75	7.75	7.37	7.75
S6	7.37	7.13	7.50	7.00	6.87

Appendix-VIII

Common Texture Terms used in Food Texture Profile Analysis

Texture terms	Explanation
Texture	Sometimes called mouthfeel, this is the physical interaction that food has in the mouth during the chewing process. This can sometimes also be interpreted by finger feel.
TPA (Texture profile analysis)	A two-bite test that imitates the action of chewing. From the results, a number of sensory related parameters can be determined.
Hardness (N)	The peak force that results from a sample being compressed to a given distance, time, or % of deformation.
Stiffness (N/mm)	It is the resistance of an elastic body to deformation by an applied force. It is an extensive material property.
Cohesiveness	The extent to which a material can be deformed before it ruptures. In other words, it refers to how a food product stays together after deformation. It is the ratio of the area under the second peak to that under the first peak.
Adhesiveness (N mm)	Sometimes referred to as stickiness, this is related to how a food adheres to the inside of the mouth surfaces during chewing.
Adhesiveness (N mm)	A combination of gumminess and springiness. This is the amount of effort that goes into preparing a solid product for swallowing.
Springiness (mm)	A food's ability to return to its original form after being compressed. It is the height that the sample recovers between the first and second compression on the removal of the deforming force.
Gumminess (N)	A combination of hardness and cohesiveness, this is the amount of effort that goes into preparing a semi-solid food for swallowing