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A Review on Functional Shrikhand Enriched with Cymbopogon Citratus and Nigella Sativa: Physicochemical Properties, Microbial Quality and Antioxidant Potential

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***Abstract* – Shrikhand is a traditional fermented dairy dessert widely consumed in India and prepared from strained curd (chakka) blended with sugar and flavoring agents. In recent years, the incorporation of herbal and plant-based ingredients into dairy products has gained attention due to their potential health benefits. Functional shrikhand enriched with Cymbopogon citratus (lemongrass) and Nigella sativa (black cumin) has emerged as a promising value-added dairy product with enhanced nutritional and therapeutic properties. The addition of lemongrass and black cumin significantly influences the physicochemical characteristics of shrikhand, including pH, titratable acidity, moisture, fat, protein and total solids. Lemongrass contains bioactive compounds such as citral, flavonoids and phenolic acids, which may slightly reduce pH and increase acidity due to their natural organic components. Similarly, Nigella sativa seeds are rich in essential oils, proteins and minerals that contribute to improved nutritional quality and flavor. These ingredients also influence the texture and stability of shrikhand by modifying moisture retention and total solids. Microbial quality is an important factor in fermented dairy products. Studies have shown that herbal additives such as lemongrass and Nigella sativa possess natural antimicrobial compounds that may inhibit the growth of spoilage microorganisms and pathogenic bacteria. This contributes to improved shelf life and microbial safety of the product when prepared under hygienic conditions. In addition, both ingredients are well known for their antioxidant properties. The phenolic compounds and flavonoids present in lemongrass and the bioactive component thymoquinone in Nigella sativa enhance the antioxidant potential of shrikhand. Antioxidant activity is commonly evaluated using DPPH and ABTS radical scavenging assays, which demonstrate the ability of functional shrikhand to neutralize free radicals. Therefore, the incorporation of these herbal ingredients can improve the nutritional, functional and health-promoting properties of shrikhand.**

Keywords - **Shrikhand, Cymbopogon citratus, Nigella sativa, functional dairy product, physicochemical properties, microbial quality, antioxidant activity.**

I. INTRODUCTION

Shrikhand is a fermented and sweetened milk product from India, derived from the Sanskrit word 'shrikhirni,' which means sugared curd. It is popular in Gujarat, Maharashtra, and some parts of Karnataka, Madhya Pradesh and Rajasthan. Its distinctive sweet-sour flavour, on the other hand, is gaining appeal in other parts of the country. Shrikhand has a semi solid consistency, smoothness, firmness, and palatability, making it ideal for snacking or eating with 'puree' or bread right after a meal (Jaybhay et al., 2019). India the process of food fermentation was probably known to the people inhabiting India in the Paleolithic and Neolithic times judging from the record of food habits. In the early Vedic period in fermented food especially dairy product have long enjoyed a reputation of enhancing the life of man. The prolongation of life, propounded that the longevity of Bulgarian was in past due to this ingesting large quantities of milk fermented with lactobacilli. Shrikhand contains appreciable amount of milk protein and phospholipids and this obtained by lactic acid fermentation through the action of Lactobacillus bulgaricus, Streptococcus lactis and Streptococcus thermophilus. There will continue to be a demand for traditional, high quality dairy product, despite increasing competition from non-dairy based products (Rathore et al., 2007).

Nutritional Composition of Shrikhand

The nutritional profile of Shrikhand indicates that it is a rich and balanced fermented dairy product. According to various studies, Shrikhand contains about 39–41% moisture (Kushwaha et al., 2019), which contributes to its soft and creamy texture. The carbohydrate content ranges from 30–32% (Srinivas et al., 2017), mainly due to added sugar, providing quick energy. Fat content varies between 12–14% (Ojha et al., 2018), enhancing flavour and mouthfeel, while protein levels are reported to be around

7–8% (Singh et al., 2017), contributing to its nutritional value. The total soluble solids range from 55–60 °Brix (Dhotre et al., 2017), reflecting its concentrated nature. Additionally, Shrikhand contains 0.70–0.85% ash (David et al., 2015), indicating mineral content, and titratable acidity ranges from 0.70–0.90% (Kumar et al., 2019), which imparts its characteristic mildly sour taste.

Different Flavoured of Shrikhand

Apple fruit pulp incorporated in Shrikhand

Sahu et al. (2021) reported that make goat milk shrikhand by including apple fruit pulp into the chakka at 15, 20 and 25% apple fruit pulp concentrations. Apple fruit pulp with a concentration of 25% was found to be acceptable. Fruits are essential components of human life since they are high in macro and micronutrients and provide fibre. The addition of apple fruit pulp increased the consistency, cohesiveness, and work of cohesion of goat milk shrikhand while also masking the goaty flavour. Orange peel extract incorporated Shrikhand.

Orange pulp extract incorporated Shrikhand

Pugazhenthi et al. (2020) reported that perform the functional shrikhand by incorporating aqueous and ethanol extracts of fresh, dried orange fruit peels at various concentrations. When the functional shrikhand with 20% aqueous and 15% ethanol extracts of fresh and dried orange fruit peels was compared to the control, it was discovered that the functional shrikhand with 20% aqueous and 15% ethanol extracts of fresh and dried orange fruit peels was the best. It was discovered that aqueous extracts (20%) of fruit peels with shrikhand can be used as a value-added functional dairy product in the human diet. Shrikhand is a traditional fermented milk product made from chakka that has a pasty texture and a moderate sweetish sour flavour. Fruit peel extracts added to the shrikhand would provide value not only in terms of diversity, but also in terms of healthfulness. The technology packages for such food products also encourage the efficient utilisation of fruit waste.

Shrikhand by blending papaya and banana pulp

According to Gupta et al. (2018) Shrikhand is prepared by blending papaya and banana pulp. Shrikhand was prepared with whole milk chakka, varied levels of papaya and banana pulp, and varying levels of sugar (30 percent by weight of chakka) at the rate of quantity of chakka 50, 40, and 30% treatment. The use of whole milk, as well as the addition of papaya and banana to the blended Shrikhand, resulted in an excellent recipe. Shrikhand from treatment T1 was found to have the best organoleptic features and received the highest organoleptic score (colour & appearance, body & texture, flavour & taste, overall acceptability). Date pulp incorporated Shrikhand.

Date pulp incorporated Shrikhand

Deshmukh et al. (2022) investigated date pulp incorporating shrikhand at three different levels of date pulp: 10%, 20%, and 30%. Date pulp is a type of fruit that can improve the nutritional and compositional quality of food while also enhancing, conserving, and expanding the functions of food. The date pulp might be utilised to produce shrikhand successfully. It aids in the functional, nutritional, and storage properties of the product.

Shrikhand production from soymilk

Soymilk, is a popular non-dairy milk alternative made from nutritious soybeans, is a popular non-dairy milk substitute. Soy shrikhand is a low-cost, high-protein, versatile soybean based cuisine. Soy shrikhand contains more protein and has less fat than buffalo milk shrikhand. The goal of this research was to investigate whether there was a way to use coagulation, desiccation, and fermentation to generate soymilk and transform it into a product (Kadam et al., 2016)

Health Benefits of Shrikhand

Shrikhand is made by fermenting milk with lactic acid bacteria. These lactic acid bacteria are well-known for their role in the fermentation of dairy products, but they can also serve as excellent ambassadors for the microbial world, which is frequently misunderstood. They are crucial not only for economic reasons, but also for maintaining and increasing human health. Lactic acid bacteria help to lower cholesterol levels in the bloodstream while also increasing vitamin B levels in the product (Bhandage et al., 2020). Shrikhand is a fermented milk product with a number of advantages over fluid milk, including ease of digestion and palatability, distinct flavour, richness, delicacy, variety, and a longer shelf life. Pomegranate fruit peel includes phytochemicals, which make food more functional and beneficial to health by acting as an antioxidant, anti-cancer, and anti-inflammatory agent (Pugazhenthi et al., 2020).

Tulsi extract and Turmeric powder, which is found in shrikhand, can help us with a range of health issues, including preventing diabetes, protecting the heart, decreasing stress, dissolving kidney stones, preventing cancer, quitting smoking, keeping our skin healthy and radiant, and repairing respiratory diseases. Tulsi is used to make Shrikhand, a healthful food (Nidhi Goswami et al., 2018). Functional foods is essential for maintaining one's health and providing the nutritional requirements of the body. Food with functional components could be added to increase customer desire and acceptability. The ashwagandha augmented shrikhand has a high protein, ash, total solids, acidity, and fat content. Medically relevant herbs in food products are not readily accepted due to their bitter taste and ugly look. Incorporating whole herbs into culinary goods may result in undesirable dietary effects. Botanical extracts with active components could be a preferable option for nutraceutical foods (Yadav et al., 2018). Date pulp in shrikhand offers a wide range of therapeutic effects, including antihyperlipidemic, anticancer, gastro protective, hepato-protective, and nephro-protective properties, in addition to antioxidant,

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antimutagenic, and immune-modulatory properties (Deshmukh et al., 2022).

Plant

Cymbopogon citratus(Lemongrass)

Plant Description

Lemon grass is a perennial monocotyledonous grass which can grow upto 6 feet in height and 4feet in width. It grows in clusters. It has long, slender, drooping bright green leaves that measures from 1.3-2.5cm in width and 3feet in length. Leaves are simple with entire margins. Flowers grow on spikes. It has a lengthy inflorescence ranging from 30 60cm. The floral arrangement of this scented grass gives it the name 'Cymbopogon'. Cymbopogon citratus is common inhabitants of Southeast Asia Taxonomic details of herbs are as follows:

- Kingdom: Plantae
- Division: Mangolipophyta
- Class: Liliopsida
- Order: Poales
- Family: Poaceae
- Genus: Cymbopogon
- Species: Citrates

Chemical Composition

Lemongrass (Cymbopogon citratus) is commonly known for its higher citral contents. Early or postponned harvesting of the lemongrass affected essential oils and also affect the citral contents. Factors like temperature, luminous intensity, soil humidity, fertilizer and maturity affected the essential oils and citral components. During maturity, the plant originates from vegetative to the reproductive stage. Overall, the yield of essential oils is highly interrelated with yield of the plant biomass. Increased quality essential oils with greater citral contents (75%) are determined from being harvested at a certain stage by the ratio of the young leaves to older leaves. Lemongrass essential oils are normally obtained by different methods like solvent, accelerated solvent dense CO2 and the Soxhlet, solidphase matrix, and the super-critical fluid extraction techniques. The advanced techniques, such as high performing Liquid chromatography in conjunction with the gas chromatograph0y (HPLC-GC) are the preferred analysis technique due to the complexity of the essential oil components. HPLC is more effective for a broad class separation of a sample, which can be introduced into a GC for further higher separation.

Nutritional properties of Lemongrass

Good nutrition is the basic pillar for growth, health and development across the entire life cycle. For the last four decades, India had invested interventions for improving the health of many individuals. Consuming a sufficient, safe and nutritious food is crucial (Anitha and Raajeswari, 2022). Table II reveals the nutritional significance of lemon grass which contains carbohydrate (55 %), crude protein (4.56 %), energy (360.6 kcal), crude fat (5.1 %). The plant is also rich in many essential minerals such as sodium (54.8 mg), potassium (59.5 mg), calcium (39.5 mg), magnesium (70 mg), iron (0.024 mg), manganese (0.952 mg), zinc (121 mg), phosphorous (89.3 mg), and phytate (11860 mg) (Ranade and Thiagarajan 2015). Lemon grass can be incorporated into health mix and supplemented to people in order to combat undernutrition as suggested by the study on formulation and supplementation of brahmi leaves incorporated health mix which was done by Anitha (2022).

Phytochemical Compounds

The herb Cymbopogon, a member of the Poaceae family, is also referred to as lemongrass. A perennial grass, lemongrass can reach a height of one meter, and has multiple stiff, green stalks that emerge from short and rhizomatous roots. A perennial aromatic grass known as C. citratus is widely grown in the Philippines and Indonesia. It is also cultivated in America and Asia, and, more specifically, in their tropical regions. The plant is mostly an indigenous herb to India, but it is also grown in several tropical and subtropical nations, including in Pakistan. Several species of lemongrass have been found worldwide: C. citratus (C. citratus), C. bombycinus, C. refractus, C. nardus and C. ambiguus. The lemongrass plant, lemongrass oil and lemongrass stalks.

Volatile Constituents of Lemongrass

Due to its commercially valuable essential oils, lemongrass is frequently used in food technology, pharmaceuticals, and traditional treatments. The terpenes, alcohols, ketones, and esters present, as well as the essential oil of lemongrass, differ according to its topographical origin, which affects its chemical makeup. The essential oil that is extracted from lemongrass is mostly found in the leaves of the plant, which are also a great source of it . Up to 5% dry weight of essential oils, primary citral with a distinctive lemonade scent, are present in the leaves. Due to the presence of citral, a cyclic monoterpene, the word "lemon" in its name refers to its distinctive lemon-like aroma. Numerous consumer products contain fragrances made using the oil of lemongrass, such as linalool (1.3%), geranial (39.0%), neral (29.4%), geraniol (1.7%), and myrcene (18.0%). Myrcene is an anti-bacterial and analgesic compound found in lemongrass, and citronellal, citronellol, and geraniol are its active ingredients. Citral, a volatile oil with a robust lemon aroma, is present in the essential oil. Citral is a mixture of two aldehydes and a stereoisomeric monoterpene; it is used to make perfumes and colored soaps, and synthesizes vitamin A. The geranial with trans isomer nature (40–62%) prevails over the neral with cis isomer nature (25–38%) in citral. Lemongrass has a long history of use in food and beverage recipes, folk medicine, and cosmetics. Due to its alluring scent, Lemongrass is utilized as a flavoring component in many non-food products, such as soaps, perfumes, candles, and insect repellents.

The essential oil of this plant is considered one of the chief volatile oils. Essential oils, perfumes, and volatile plant byproducts have a significant advantage in both the perfume and folk medicine businesses. Many essential oils and the substances that make them up have pharmacological capabilities that act as anti-inflammatory, antioxidant, and anti-cancer agents. Lemongrass essential oil carries great importance, with citral as the main element. The citral content fluctuates from 44.3–91.4% to 79–91.5% in the essential oil. Other important volatile constituents are β-myrcene (11%) and geraniol (1.9%).

The structures of the main volatile constituents.

Phenolic Constituents of Lemongrass

Phenolic compounds are a diverse class of plant secondary metabolites, including phenolic acids, flavonoids, stilbenes, lignans, coumarins, curcuminoids, and other polyphenols. Flavonoids are the most abundant phenolic constituents, containing more than ten thousand compounds. The highest concentration of caffeic acid (445.21 ± 32.77 μg/g), p-coumaric acid (393.32 ± 39.56 μg/g), chlorogenic acid (377.65 ± 4.26 μg/g), quinic acid (161.52 ± 17.62 μg/g), and quercetin-3-glucoside (151.35 ± 11.34 μg/g) were reported by (Ali et al., 2003) Moreover, catechin, tricin, pyrogallol, diosmin, procyanidin B2, ferulic acid, protocatechuic acid, and p-hydroxybenzoic acid have also been reported in Australian lemongrass. Lutein, apigenin, and their 6,8-glucosides were also reported by Shah et al., 2011).

Medicinal Properties

Lemongrass contains several important bioactive compounds which are useful in several health issues. These active compounds are normally found in the leaves. The various methodologies used in extracting such bioactive compounds. The root of lemongrass is also being used as chewing stick for mouth cleaning in several parts of the world (Sawyerr, 1982). Essential oil is one of the important components of lemon grass extracts and its applications include co-ingredients for perfumes and cosmetics. Its high citral composition has made it important for several chemical syntheses (Negrelle and Gomes, 2007). Similarly, investigations carried out on different lemongrass extracts showed other important therapeutic potentials such as anti-cancer, antihypertensive and anti-mutagenicity. Others include non-toxic properties, anti-diabetic, anti-oxidant, anxiolytic, anti-nociceptive and anti-fungi (Shah et al., 2011).

Initially, the use of lemongrass extract in folk medicine for the treatment of certain ailment was disputed, but recent findings have confirmed its efficacy (Adejuwon and Esther, 2007). Despite this, lemongrass tea and its essential oils is becoming unpopular especially among developing nations. This might be due to lack of awareness of published results on the efficacy of the extracts on several health related issues. Hence, the focus of this review is to concisely document all reported biological properties of lemongrass extracts (infusion and decoction) and essential oils. Similarly, suggestions regarding future directions in this area of study were thoroughly prepared to ease the path towards elucidation of inherent medicinal properties of lemongrass. Lemon grass extracts contained several medicinal chemical components which reside in its essential oil and aqueous extract. Detail information on performance of all these compounds are concisely presented in next section.

Anti-inflammatory properties

Tissue inflammation is one of the main health issues worldwide. The hike in its prevalence has been attributed to sophisticated lifestyles occasioned by technological advancement. Therefore, inflammation accounts for more cases of mortality among people. Importantly, it has been linked with other health problems like cancer, cardiovascular rheumatoid, neurodegenerative and diabetes (Jaswir and Monsur, 2011). Inflammation in animal tissue is usually triggered by physical stress or when chemical inducers (e.g. lipopolysaccharide) are present within the tissue composition. Mechanistically, inflammation will occur when lipopolysaccharide (LPS) is incubated with macrophages thereby leading to secretion of pro-inflammatory mediators such as nitric oxide (NO) and prostaglandin E2 (PGE2). Other inductive factors include reactive oxygen species (ROS), cytokines which includes tumor necrosis factor- TNF-α, interleukins and up-regulation of nuclear factor keppa-B cells proteins (NF-κB).

Anti-oxidant properties

Oxidation is a fundamental process in human cells, tissue and systems leading to formation of reactive oxygen species (ROSs) which include hydrogen peroxide (H2 O2), superoxide anion (O2-) and free radicals (Heo et al., 2003). Due to its reactivity, ROSs damage biochemical components like cell membrane, cellular lipids, proteins and DNA (Devasagayam et al., 2004). Additionally, ROS(s) function as major inducer of several health issues like atherosclerosis, rheumatoid arthritis and muscle destruction. Others are cataracts, certain neurological disorders, cancer and ageing. Antioxidants have to be present in the body to offer protective mechanism against damaging effects of oxidation process caused by these radicals (Finkel, 1998; Thannickal and Fanburg, 2000).

Researchers have identified antioxidant potentials of lemongrass extracts and documented their abilities to reduce ROSs. Such mechanism include inhibition of lipoperoxidation and decolorization of 2,2 diphenyl-1-picrylhydrazyl (DPPH) (Sharma and Bhat, 2009; Mirghani et al., 2012). Infusions and decoctions prepared from lemongrass showed anti-oxidant properties by scavenging superoxide anion, inhibiting lipoperoxidation and decolorizing DPPH. These effects are higher in infusion than decoction (Cheel et al., 2005). Similarly, lemongrass infusion exhibited stronger antioxidant activities in relation to other extracts (methanolic, 80% aqueous ethanol and decoction). Further studies revealed that tannin and flavonoid fractions of oil-free infusion extract were most active anti-oxidative agents compared to phenolic acids fraction (Figueirinha et al., 2008). Aqueous ethanol extract was reported to exhibit antioxidant properties by decreasing reactive oxygen species production and lipid peroxidation, as well as, increasing superoxide dismutase activity and glutathione formation (Tiwari et al., 2010). Recently, essential oil of lemongrass was also reported to show antioxidant property by DPPH scavenging test. The results showed that both leaves and stalk extracts possess radical scavenging ability in a dose dependent manner (Mirghani et al., 2012).

Anti-bacteria potential

Anti-bacterial activity in extracts of plant materials has been elucidated from various sources in recent times with promising results. This characteristic has also been investigated in the volatile oil portion of the aqueous extract of lemon grass (Grace et al., 1984). Among the major bioactive compounds identified in the oil were α-citral (geranial) and β-citral (neral) components. These components demonstrate their antibacterial activity by inhibiting the growth of both Gram positive and Gram negative bacteria. However the third component- myrcene possess no antibacterial activity individually but do enhance activity when combined with others (Grace et al., 1984).

Anti-fungi properties

The action of essential oils extracted from lemon grass decoction against both pathogenic and edible fungi is of immense contribution as investigated by researchers. Lemon grass oil showed a promising prospect among several essential oils by inhibiting the growth of fungi cells which are implicated in secreting mycotoxins during storage of grains and other food products (Fandohan et al., 2008; Nguefacka et al., 2012). Here, the synergistic effects of oil fractions showed both synergistic and antagonistic effects among different portion of characterized oils (Viana et al., 2000; Nguefacka et al., 2012). Essential oil fraction of lemon tea has been reported to exhibit anti-fungal effects against filamentous fungi of different classes thereby showing its broad spectrum of activity against both disease causing and non-pathogenic fungi. Similarly, the oil is capable of inactivating disease causing yeast cells (Candida spp.) by inhibiting their growth (Dharmendra et al., 2001).

Anti-obesity and antihypertensive activity

Several investigations have been carried out on the potentials of lemon grass extract as a source of hypolipidemic and hypoglycemic substances which may lower the risks of hypertension and obesity. Available reports showed that citratus aqueous extracts when fed to rats at 500 mg/kg/day led to significant reduction in hypoglycemic index in spite of counter regulatory factors such as catecholamine, cortisol and glucagon. Hypolipidemic effect was recorded with noticeable reduction in low density lipids levels in the blood stream. The mechanism by which the tea effectively performs these effects remained elusive but several researchers have associated it with increased insulin synthesis and secretion (hyperinsulinemia) or increased peripheral glucose utilization (Adejuwon and Esther, 2007).

Antinociceptive properties

The possibility of lemon tea possessing antinociceptive effects has been well researched over the years. Earlier reports showed that lemon grass extracts has little or no positive actions thereby negating the claims in folk medicine (Carlini et al., 1986; Leite et al., 1986; Souza-Formigoni et al., 1986). However, recent investigations presented contra reports. According to Viana et al. (2000), lemon grass tea possessed antinociceptive property which was evident in positive results from different nociceptive testes performed on the extract. Essential oil of lemon grass, which contained citral but no myrcene was investigated for their antinociceptive activities using three experimental models of nociception in mice. The hot plate test showed that response to stimulus by the mice was increased by essential oil administered intra-peritoneally (I.P.) while writhing by acetic acid induction showed that intra-peritoneal and oral administration of essential oil caused inhibition of abdominal contraction in a dose dependent manner. In the formalin test, licking time was drastically inhibited by essential oil administered I.P. at both first and second phase of the experiment (Viana et al., 2000). They reported that opioid receptors are involved in the antinociceptive action since antagonist naloxone blocked the effects of the tested essential oils present in the extract. Same group of investigators opined that the discrepancy noticed with regards to earlier reports could be due to differences in plant chemotypes used for analysis. Citral, obtained from lemongrass, has been reported to possess anti-nociception properties according to the findings of Quintans-Junior et al. (2011) using acetic acid induced writhing and nociception induced by formalin. It was concluded that citral is capable of exhibiting peripheral antinociceptive property by inhibiting writhing and nociception.

Fortification of Lemongrass in Dairy Products

The yogurt was prepared with two different commercial starters of probiotics [Lactobacillus acidophilus (LA-5), Bifidobacterium lactis (BB-12)], incorporation with Streptococcus thermophiles and two various concentrations of lemongrass powder or extract (0.5% and 1%). The data showed that lemongrass extract inhibited all microorganisms' growth at a concentration of 36 µl/mL for fungi species (Aspergillus niger, Aspergillus flavus and Penicillium spp.) and 48 µl/mL for bacteria species (Pseudomonas fluorescens, aeruginosa, fragi and Aeromonas hydrophila, caviae, sobria). Lemongrass powder or extract produced an alternative, stable color and stable quality of yogurt during frozen storage. Sensory evaluation of frozen yogurt with lemongrass powder 0.5% had acceptable quality characteristics with higher antioxidant effect (Thiobarbituric acid values 1.02 mg malonaldehyde /kg) after 30 days of frozen storage. The viability loss during frozen storage of commercial probiotic cultures Lactobacillus acidophilus (LA-5) and Bifidobacterium lactis (BB-12) decreased between 0.7, 1.15 and 0.76, 1.36 log CFU/g, respectively in all treatments. The population of these microorganisms remained above 10□ CFU/g.

Nowadays, there is an exponential growth in herbal functional foods as consumers everywhere desire diets healthier. Lemongrass (Cymbopogon citratus) is a grass that belongs to Cymbopogon genus and Graminaceae family (Adeneye and Agbaje, 2007). Lemongrass has phytochemicals such as flavonoids, tannins, alkaloids and essential oils. The prefix lemon

attributes to its lemon-like typical odor due to the presence of citral, and citral is a combination of two steroisomeric monoterpene aldehydes (Majewska et al., 2019). The aqueous lemongrass extract is commonly used as an aromatic drink and the whole plant is well incorporated into many various traditional foods for its lemon flavor (Figueirinha et al., 2008).

Milk filtration methods rely on the membrane's selectivity for proteins in particular, as well as on the membrane general selectivity for proteins and flow rate, which are governed by the membrane pressure and flow rate laws. Based on the findings, the proper operating parameters were established, which included a flow rate of 0.15 L/min and 2 bar, as well as the percentage of particulates and lactose isolation, in order to concentrate the milk to 2.7 times. Taking into account the flow rate entering the system, the size of the pores, the molecular weight of the protein molecules and the total number of dissolved components in the raw milk, we can deduce that the flow rate is all connected. The results of the study also showed that adding 200 mg/L of lemongrass extract to milk significantly reduced the total bacterial count, which confirms to us the effectiveness of lemongrass as a preservative in terms of microbial growth. It was found the change of the total solid and protein were excellent percentages with time of filtration and also more acceptable to the consumer in terms of flavor, color and overall appearance, making it more attractive.

Nigella sativa

Nigella sativa, commonly known as black seed, is an annual herbaceous plant with the following morphological characters:

S. No.	Botanical aspects	Morphological Features	References
1	Habit	An erect and branched annual herb.	Salehi *et al.*, (2021)
2	Stem	The stem is typically 20-90 cm tall, often with a slight hairiness.	Akhtar *et al.*, (2016)
3	Leaves	The leaves are alternate and deeply dissected, resembling feathery foliage	Majeed *et al.*, (2021)
4	Flowers	The flowers are solitary, typically white or pale blue, with five to ten delicate petals.	Ali and Blunden, (2003)
5	Fruits	The fruits are inflated capsules containing numerous small, black, angular seeds	Salem, (2005)

Its taxonomy and nomenclature are as follows:

- Plant name: N. sativa
- Kingdom: plantae
- Order: Ranunculales
- Family: Ranunculaceae
- Genus: Nigella
- Species: Sativa

Morphological Descriptions of Nigella sativa

Nigella sativa is a hermaphrodite, erect, annual herb, with a more or less branched stem, pinnately dissected leaves; plant height 35-45 cm with determinate flowering patterns. The flower terminates the main shoot and ends with the flowers on the lowermost branches. The leaves are 2.5-5.0 cm in length, linear to lanceolate in shape; flowers are delicate, usually pale blue and white in colour, 2.0-2.5 cm across, solitary and peduncular. The seed bearing capsule is 1-1.5 cm long. The perianth is differentiated into an outer whorl of five, 15–20 mm long, whitish, petaloid sepals and an inner whorl of eight, 7–8 mm long, nectariferous petals. The flowers are protandrous with 5 to 10 petals and characterized by the presence of nectaries. The androecium comprises a large number of stamens, which shed their pollens as the filament curves outward during the male phase.

Traditional Significance

Nigella sativa, commonly known as black seed, has a rich history of traditional use in various cultures. It has been employed to address a wide range of health concerns, including respiratory infections, skin conditions, and digestive issues. Traditional medicine systems, such as Ayurveda and Unani, have utilized black seed to bolster the immune system and promote overall well-being. Additionally, it has been used to alleviate pain, reduce inflammation, and support respiratory health. However, it is important to note that the specific traditional uses of Nigella sativa may vary depending on cultural and geographical factors. Nigella sativa has been traditionally used to address a wide range of health issues. These include respiratory problems like asthma, bronchitis, and cough, as well as digestive disorders such as indigestion and flatulence. Additionally, it has been employed to manage skin conditions, liver and kidney function, and even certain cardiovascular diseases. More than 2000 years ago, Nigella sativa seeds were used for the first time in Middle Eastern traditional medicine to treat a range of diseases. N. sativa seeds have been used in traditional Arabic herbal medicine for the treatment of various illnesses like Zeeq Un Nafs (asthma), Ziabetus (diabetes),

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Siman-e-Murit (obesity), Sartan (cancer), Sual Muzmin (chronic cough), Zagatuddam Qawi (hypertension), Tayammum-e-Dam (dyslipidemia), and others. Early herbalists referred to Nigella sativa as “the herb from heaven” and characterized it as a miraculous plant. Because of its multiple applications, Nigella sativa has been given the Arabic name “Habbatul barakah,” which means the seed of blessing.

Biochemical properties

Nigella sativa, commonly known as black cumin or black seed, has been extensively studied for its wide range of pharmacological properties due to the presence of numerous bioactive constituents. Here are the main chemical constituents, along with references:

S. No.	Chemical Category	Bioactive constituents	Constituent properties	References
1	Quinone	Thymoquinone (TQ), Nigellone	Antioxidant, Antiinflammatory, Anticancer and Broncho-dilator	Ahmad *et al.* (2013) and Gali *et al.*(2006)
2	Alkaloids	Nigellidine, Nigellicine, and Nigellimine	Bronchodilator	Randhawa *et al.* (2011)
3	Saponins	Alpha-Hederin	Anticancer, Hepatoprotective	Chehl *et al.* (2009)
4	Essential Fatty Acids	Linoleic and Oleic Acids	Anti-inflammatory	Buritis *et al.*(2000)
5	Proteins and Amino Acids	Arginine and Glutamic Acid	Immunomodulator	Atta *et al.* (2003)
6	Volatile Oils	p-Cymene, Alpha Pinene, Limonene	Aromatic properties	Ali *et al.*(2003)
7	Vitamins	B1, B2, B3	Nutritional value	Tembhurne et *al.* (2014)
8	Minerals	Calcium, Iron and Zinc	Nutritional value	Tembhurne *et al.* (2014)
9	Flavonoids	Kaempferol, Quercetin and Rutin	Antioxidant	Jassir *et al.* (1992)

Chemical structure of different bioactive constituents of Nigella sativa

Pharmacological Properties

Several scientists substantiated the traditional observation through various experimental procedure. The seeds are the frequently used. The ease of availability of seeds helps in extensive use in traditional system of medicine the presence of different phytoconstituents like Thymoquinone, alkaloid, flavonoids and saponins is proposed to be responsible for various pharmacological actions. Scientific evaluation and study authenticate the ethnomedicinal and pharmacological effects. Different pharmacological findings obtained from N. sativa have been tabulated.

Antidepressant activities

The neuropharmacological activity of N. sativa extracts were investigated. The researchers assessed the effects of the plant’s extracts on the central nervous system (CNS) using various animal models. The results showed that Nigella sativa extracts exhibited significant neuropharmacological effects, including anxiolytic, sedative, and anticonvulsant activities. These effects were attributed to the bioactive compounds present in N. sativa, particularly thymoquinone, which is known for its antioxidant and neuroprotective properties. The study suggested that Nigella sativa could be a promising candidate for managing neurodegenerative disorders and other CNS-related conditions. The long-term administration of N. sativa was evaluated for its effects on nociception, learning, and memory in rats. The researchers found that prolonged use of Nigella sativa significantly reduced improved learning and memory performance in cognitive tasks, suggesting potential neuroprotective and cognitive-enhancing effects. The study concluded that N. sativa may be beneficial in managing pain and improving cognitive function, making it a valuable natural compound for neurological health.

Anticonvulsant activity

The effects of the hydro-alcoholic extract of N. sativa on scopolamine-induced spatial memory impairment in rats were investigated. The researchers aimed to explore the potential of N. sativa as a treatment for memory deficits associated with neurodegenerative conditions. The results showed that the administration of N. sativa extract significantly improved spatial memory in rats, as evidenced by enhanced performance in the Morris water maze test. The study suggested that N. sativa might exert its memory-enhancing effects through antioxidant properties and modulation of cholinergic pathways, offering potential therapeutic benefits for cognitive disorders.

Antidiabetic activity

Diabetes was induced in rats with a single injection of Streptozocin (STZ) at 65 mg/kg, and they were divided into six groups: healthy reference (HR), diabetic (DM), DM treated with α-lipoic acid (α-LA), L-carnitine, Nigella sativa, or a combination of the three. After 30 days, glucose metabolism (fasting blood glucose, insulin, HOMA, C-peptide), lipid metabolism (cholesterol, triglycerides), and oxidative stress markers (TAC, GST, 8 OH-dG) were assessed. α-LA or Nigella sativa reduced blood glucose, while the combination of all three compounds increased insulin and C-peptide levels, enhanced antioxidant activity, and reduced DNA damage. HOMA-β was higher in the α-LA and combination groups, but changes in cholesterol and triglyceride levels were not significant. Rats were divided into five groups: control, untreated STZ-diabetic, and those treated with aqueous Nigella sativa extract, Nigella sativa oil, or thymoquinone. The treatments (2 mL/kg N. sativa extract, 0.2 mL/kg oil, or 3 mg/mL thymoquinone) were administered 6 days a week for 30 days. Serum insulin and glucose levels, superoxide dismutase (SOD) activity, and pancreatic malondialdehyde (MDA) were measured, with electron microscopy used to observe subcellular changes. Diabetes increased tissue MDA and serum glucose while decreasing insulin and SOD. Treatment with Nigella sativa extract, oil, and thymoquinone significantly reduced MDA and glucose, and increased insulin and SOD. Microscopically thymoquinone corrected most STZ-induced damage, including DNA damage and mitochondrial changes, while the Nigella sativa extract also improved these effects, though to a lesser degree. N. sativa oil restored insulin levels but did not normalize glucose. These findings suggest that N. sativa extract and thymoquinone protect against STZ-induced diabetes by reducing oxidative stress, preserving pancreatic β-cell integrity, and potentially offering therapeutic benefits for diabetic treatment and β-cell protection.

Anticancer

Thymoquinone (TQ), the main component of black seed, has shown potent chemopreventive effects against skin tumors in mice. However, its mechanism of action had not been fully explored. In this study, we examined the cellular and molecular events in primary mouse keratinocytes and skin carcinoma cells (SP-1 and I7) treated with non-cytotoxic concentrations of TQ. TQ reduced the proliferation of neoplastic keratinocytes by 50%, with papilloma cells being more sensitive to TQ's growth inhibitory effects than spindle cancer cells. TQ induced G0/G1 cell-cycle arrest in SP-1 cells, increasing p16 expression and decreasing cyclin D1, while in I7 cells, it caused G2/M arrest, enhancing p53 expression and reducing cyclin B1. Over time, TQ induced apoptosis in both cell lines by increasing the Bax/Bcl-2 ratio and decreasing Bcl-xL, with a stronger effect in SP-1 cells. These findings suggest that TQ may be particularly effective as a chemopreventive agent during the early stages of skin tumor development. The study aimed to evaluate the antitumor activity of thymoquinone (TQ) and thymohydroquinone (THQ) both in vitro and in vivo. In the in vitro experiments, L929 mouse fibroblasts and tumor cell lines (squamous cell carcinoma (SCC VII) and fibrosarcoma (FsaR)) were treated with 0.1 or 0.01 mg/ml of TQ or THQ for 24 hours, and cytotoxicity was assessed using crystal violet staining. Both TQ and THQ demonstrated significant cytotoxic effects ($p \leq 0.01$), with a dose-dependent response that was more pronounced in tumor cells compared to fibroblasts. In vivo, the compounds were administered through four intratumoral injections at a dose of 5 mg/kg in murine tumor models, resulting in a tumor growth inhibition (TGI) of 52%, which was statistically significant ($P \leq 0.05$). These results suggest that THQ exhibits notable antitumor potential, with the possibility of enhanced effects at higher doses. Further research could explore optimizing these compounds for therapeutic use.

Antibacterial activity

Bakathir and Abbas (2011), the antibacterial effects of N. sativa ground seeds mixed with water were evaluated. The research aimed to explore the antimicrobial properties of Nigella sativa, which has been traditionally used for its health benefits. The study involved testing the antibacterial activity of the ground seeds against various bacterial strains, including both Gram-positive and Gram-negative bacteria. The results demonstrated that the water extract of Nigella sativa seeds exhibited significant antibacterial activity, effectively inhibiting the growth of several pathogenic bacteria. This study highlights the potential of N. sativa as a natural antibacterial agent with therapeutic applications. The study by Hannan et al. (2008), the antibacterial activity of Nigella sativa was evaluated against clinical isolates of methicillin-resistant S. aureus (MRSA), a bacterial strain known for its resistance to many antibiotics. The researchers tested the effectiveness of N. sativa extracts against MRSA strains collected from clinical settings. The results demonstrated that N. sativa exhibited significant antibacterial activity, inhibiting the growth of MRSA. This study highlights the potential of N. sativa as an alternative or adjunctive treatment for infections caused by MRSA, particularly in the context of increasing antibiotic resistance.

Antifungal Activity

In the study by Aljabre et al. (2015), the dermatological effects of N. sativa were explored, focusing on its potential therapeutic benefits for various skin conditions. The researchers reviewed the medicinal properties of Nigella sativa, particularly its anti-inflammatory, antimicrobial, and antioxidant activities, which contribute to its skin-healing properties. The study highlighted that N. sativa oil and its active compounds, such as thymoquinone, could be effective in treating skin disorders like acne, eczema, and psoriasis. The results suggested that N. sativa could be a promising natural remedy for improving skin health and managing dermatological conditions.

Immunomodulatory Activity

In the study by Ghonime et al. (2011), the immunomodulatory effects of three herbal plants,

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including N. sativa, were evaluated in a murine model. The researchers investigated the impact of these plants on various immune parameters, including spleen cell proliferation, antibody production, and cytokine release. N. sativa demonstrated significant immunomodulatory activity by enhancing the immune response, particularly through the activation of T-cell and B-cell functions. The study concluded that N. sativa could serve as an effective immunostimulant with potential therapeutic applications for boosting immune function and improving resistance to infections.

Gastrointestinal Effects

The effects of N. sativa oil on gastric secretion and ethanol-induced ulcers in rats were evaluated. The researchers aimed to assess the protective and therapeutic potential of Nigella sativa oil against gastric ulcers, which are commonly induced by ethanol consumption. The results showed that N. sativa oil significantly reduced gastric acid secretion and provided protective effects against ethanol-induced ulcers. The study concluded that the oil's gastroprotective properties may be attributed to its antioxidant and anti-inflammatory effects, suggesting N. sativa oil as a potential natural remedy for gastric disorders (Asif et al., 2025). N. sativa oil and its bioactive components, particularly thymoquinone, help reduce gastric acid secretion, enhance mucus production, and exhibit anti-inflammatory and antioxidant properties. These effects contribute to the protection of the gastric mucosa from damage induced by irritants like ethanol or NSAIDs.

Anti-inflammatory and Analgesic Effects

In the study by Alemi et al. (2013), the anti-inflammatory effects of N. sativa seeds and callus extracts were investigated, specifically focusing on their thymoquinone content. The researchers tested these extracts on mixed glial cells to assess their ability to modulate inflammatory responses. The results showed that both seed and callus extracts significantly reduced inflammatory markers in the glial cells, with thymoquinone being identified as the primary bioactive compound responsible for these effects. The study concluded that N. sativa extracts, rich in thymoquinone, possess potent anti-inflammatory properties, making them promising candidates for inflammatory conditions treatment.

Antioxidant Activity

The antioxidant activity and phenolic content of phenolic-rich fractions obtained from black cumin (Nigella sativa) seedcake were evaluated. The researchers found that the seedcake fractions exhibited significant antioxidant activity, attributed to their high phenolic content. The study demonstrated that these phenolic compounds played a key role in neutralizing free radicals and reducing oxidative stress. The findings suggest that Nigella sativa seedcake, a byproduct of oil extraction, could be a valuable source of natural antioxidants for use in food and pharmaceutical industries.

The effects of thymoquinone, the active compound in N. sativa, on oxidative stress and inflammatory cytokine responses were investigated in collagen-induced arthritis in Wistar rats. The researchers found that thymoquinone significantly reduced oxidative stress by enhancing antioxidant enzyme activity and decreasing the levels of malondialdehyde, a marker of lipid peroxidation. Additionally, thymoquinone modulated the expression of inflammatory cytokines, reducing levels of pro-inflammatory markers such as TNF-α and IL-6. These findings suggest that thymoquinone has potent anti-inflammatory and antioxidant properties, which may offer therapeutic benefits in conditions like rheumatoid arthritis.

Antiviral Activity

The antibacterial effects of lemon and black seed (Nigella sativa) oils were evaluated against bacterial isolates from HIV-positive patients. The researchers found that both oils exhibited significant antibacterial activity, with Nigella sativa oil showing strong inhibitory effects on various bacterial strains. The study concluded that Nigella sativa oil, due to its antibacterial properties, could be a potential therapeutic agent for managing infections in immunocompromised individuals, such as those with HIV, highlighting its role in combating bacterial infections (Asif et al., 2025). The effects of a N. sativa concoction were evaluated for its potential to induce sustained seroreversion in an HIV patient. The researchers observed that the patient, after using the Nigella sativa concoction, showed signs of seroreversion, which refers to a sustained reduction in the viral load to undetectable levels. The study suggested that Nigella sativa might possess therapeutic potential in HIV treatment, possibly through its immune boosting and antiviral properties, offering a complementary approach to conventional HIV management.

II. PHYSIO CHEMICAL PROPERTIES OF SHRIKHAND

pH

The pH content in the developed product shrikhand as found to be 4.72±0.01, 4.70±0.01, 4.68±0.01, 4.68±0.01 and 4.67±0.01 per cent for treatment T0, T1, T2, T3 and T4, respectively the treatment T0 and T2 was significantly different from each other at 5% level of significance. The results were in accordance with the findings of (Patel and Chakraborty, 1985; David, 2015) who obtained pH values of 4.1 and 4.36 respectively in shrikhand. The pH content in the developed product as found to be 4.68, 4.50, 4.40 and 4.30 per cent for treatment T1, T2, T3 and T4, respectively (Bhandage et al., 2020). Kolape et al. (2010), observed that the pH of shrikhand was changed due to addition of papaya pulp. The pH of shrikhand of treatments T1, T2, T3 and T4, was 4.38, 4.47, 4.55 and 4.63, respectively. He indicated that pH increased with increased level of papaya pulp added in the shrikhand.

Titratable acidity

The mean titratable acidity of control shrikhand as found to be 0.81±0.01, 0.82±0.02, 0.90±0.01, 0.93±0.01 and 0.95±0.02 for treatment T0, T1, T2, T3 and T4 percent lactic acid respectively. Statistical analysis revealed slightly significant difference in titratable acidity between both controls and treatment shrikhand sample. The results were also in accordance with the legal standards of IS: 95321-1980. According to Food safety and standards regulations (2010), the titratable acidity of shrikhand should not be more than 1.4 per cent lactic acid. All shrikhand samples met with this legal standard (Bhandage et al., 2020). Bhandage et al. (2020) reported that the average acidity per cent of finished product found to be 1.03, 1.29, 1.35 and 1.47 per cent for treatment T1, T2, T3 and T4, respectively. David (2012), studied preparation of herbal shrikhand prepared with basil (Ocimum basilicum) extract and observed increase in acidity with increase in basil extract.

Fat

The mean fat per cent of control shrikhand as found to be 7.85±0.12, 7.91±0.12, 8.50±0.12, 8.57±0.12 and 8.67±0.12 for treatment T0, T1, T2, T3 and T4 percent respectively. Fat per cent of shrikhand showed a statistically significant difference between (T0) control shrikhand and (T2) treatment. shrikhand which was in close resemblance with the findings of (Bhandage et al., 2020) who obtained fat values between 8.21 to 8.75 per cent respectively. This result was in similar with the legal standard specified for shrikhand (FSSR, 2011). The fat content ranged between 8.21 to 8.75 per cent. The highest value of fat content was recorded for treatment T1 (8.75 per cent) and lowest value was for treatment T4 (8.21 per cent) and found that the kiwi fruit was reduced the fat content of shrikhand (Bhandage et al., 2020).

Protein

The average protein content of the shrikhand samples was found to be 7.30±0.05, 7.58±0.06, 7.65±0.04, 7.90±0.07, and 8.00±0.09 per cent for treatment T0, T1, T2, T3 and T4 percent respectively. There was significantly difference between the protein content of both controls and treatment shrikhand sample. Similar result was reported by incorporation of WPC had significantly increased the protein per cent in the treatment group of shrikhand (Shaji and Thomas, 2018) which was in close resemblance with the findings of (Sameem et al., 2018) which obtained the protein content of product ranged from 9.1- 8.41 per cent.

Moisture

The average moisture content of finished product was to be found as 42.00±0.13, 41.69±0.16, 41.63±0.09, 40.75±0.12 and 40.57±0.11 per cent for treatment T0, T1, T2, T3 and T4 percent respectively. It is observed that significantly difference between the moisture content of both controls (T0) and treatment (T2) shrikhand sample. (Sameem et al., 2018) reported that the level of dragon fruit pulp increased, the moisture content in shrikhand also increased. It shows that average mean scores of moisture ranges from 42.7, 43.98, 45.25 and 46.52 for the treatments T0, T1, T2 and T3, respectively. (Sharma et al., 2017) stated that moisture content in shrikhand increased may be due to increase in the proportion of sapota pulp. the moisture content of control shrikhand (50.23%) in this study was in accordance with the finding of (Mehta, 2013) who observed 45 to 52% of moisture in shrikhand collected form Mumbai city. It was observed that the average moisture content of finished product were to be found as 40.13, 43.52, 45.49 and 48.05 per cent in treatments T1, T2, T3 and T4, respectively. It was also observed that the lowest moisture content was in T1 (40.13) and the highest was found in T4 (48.05). All treatments significantly difference from each other. This might be due to due to higher water holding capacity of interactive mixture of kiwi fruit and milk solids (Bhandage et al., 2020). Sameem et al. (2018), reported that the level of dragon fruit pulp increased, the moisture content in shrikhand also increased. It shows that average mean scores of moisture ranges from 42.7, 43.98, 45.25 and 46.52 for the treatments T0, T1, T2 and T3, respectively. Sharma et al. (2017), studied the effect of percentage incorporation of sapota pulp on physico-chemical characteristic of cocoa shrikhand and shows that the increase in proportion of sapota pulp in shrikhand, moisture content in shrikhand also increased. Moisture content increases from 38.04 to 40.32 for treatment T0 to T3. Moisture content in shrikhand increased may be due to increase in the proportion of sapota pulp.

Total Ash

The average protein content of the shrikhand samples was found to be 0.57±0.001, 0.57±0.001, 0.58±0.001, 0.58±0.001 and 0.58±0.001 per cent for treatment T0, T1, T2, T3 and T4 percent respectively. (Chorage et al., 2018) it also reported that ash content of shrikhand for treatment T0, T1, T2, T3 and T4 were 0.53, 0.51, 0.47 and 0.45 per cent, respectively. Also, the results were also in accordance with the (Singh and Kumar, 2017) they also reported that ash content of wood apple pulp shrikhand for treatment T0, T1, T2 and T3 were 0.88, 0.82, 0.77 and 0.74 per cent, respectively. The average ash content of finished product was 0.96, 0.92, 0.87 and 0.80 percent in treatment T1, T2, T3 and T4, respectively. It was also observed that the lowest ash content was in T4 and highest was found in T1. All the treatments were significantly different from each other and decreased the ash content as the kiwi fruit pulp was increased. Singh and Kumar (2017), studied the wood apple blended shrikhand. The ash content of wood apple pulp added shrikhand was increased with increase in the proportion wood apple pulp. It also reported that ash content of wood apple pulp shrikhand for treatment T0, T1, T2 and T3 were 0.88, 0.82, 0.77 and 0.74. per cent, respectively Chorage et al. (2018), also reported that ash content of shrikhand for treatment T0, T1, T2, T3 and T4 were 0.53, 0.51, 0.47 and 0.45 per cent, respectively. The ash content of shrikhand was decreased with increase in the proportion of yoghurt culture and ginger juice in shrikhand. It was also showed that increasing yoghurt culture and ginger juice proportion in the blend there was decrease in ash content of shrikhand. It may be due to decrease in the total solid content.

Total solids

It was observed that the average moisture content of finished product was to be found as 58.00±0.01, 58.31±0.02, 58.37±0.01, 59.25±0.03 and 59.42±0.02 per cent for treatment T0, T1, T2, T3 and T4 percent respectively. (Sameem et al., 2018) found similar results in n dragon fruit pulp added shrikhand the mean value for total solid of shrikhand samples were observed as 57.33, 56.03, 54.75 and 53.48 for T0 T1, T2 and T3 respectively. (David, 2015) reported that the highest mean value for total solids percentage in shrikhand with basil (Ocimum basilicum) extract was 60.12 per cent. Bhandage et al. (2020) observed that the average total solid content of treatment T1, T2, T3 and T4 were 59.87, 56.48, 54.52 and 51.96, per cent, respectively. The values of total solid content in all the treatment significantly differed from each other. It was also observed that the total solid content was in decreasing order from treatment T1 to T4. Sameem et al. (2018), found similar results in dragon fruit pulp added shrikhand. They reported that blending of dragon fruit pulp in shrikhand resulted in decreased in total solid content with increasing concentration of dragon fruit pulp proportion in the blend. The mean value for total solid of shrikhand samples were observed as 57.33, 56.03, 54.75 and 53.48 for T0 T1, T2 and T3, respectively. Sharma et al. (2017), also observed similar trends in their study and mentioned the same reason that as total solid content decreased with increase in the proportion of sapota pulp and cocoa powder in the blend of shrikhand.

III. MICROBIAL ANALYSIS

Shimar Mishra et al. (2022) pointed that the total microbial load (SPC): Effect of storage on SPC (107x Cfu/ml) of developed Shrikhand during storage at 5-7 ºC. The SPC count on first day was 17.50 x 107 Cfu/ml. The SPC count declined from 17.50 x 107 Cfu/ml to 12.25 x 107 Cfu/ml for Shrikhand stored at 5-7 ºC respectively on 7th day. The SPC count of Shrikhand stored at 300C was decreased for 17.50 x 107 Cfu/ml to 12.25 x 107 Cfu/ml in 24 hrs. Kolpe et al. (2010), who reported SPC from 18.25 to 23.25 x 106 /ml of control sample of shrikhand prepared to evaluation of microbial quality of papaya shrikhand. SPC from 3.31 to 7.34 x 107 /ml of branded dahi sold in various market of Pakistan, reported by Yonus et al., (2013).

Reshma et al. (2018) reported that the coliforms were present on the 1st and 5th day of storage. The mean coliform count of control shrikhand (C) were 1.05±0.05, 0.33±0.21 log cfu/g on 1st and 5th day of storage respectively. The corresponding values for T1, T2 and T3 groups shrikhand were 0.98±0.21, 0.50±0.22, 1.18±0.08, 0.33±0.21 and 1.10±0.06, 0.33±0.21 log cfu/g respectively for the same period. Coliforms were absent on 10th and 15th day of storage in all shrikhand samples. Shimar Mishra et al. (2022) noted that the Coliform count: Since the low pH and acidity of fermented milk inhibits the development of these microorganisms, fermented milk products are not ideal for their growth. Coliforms were found to be missing in both fresh and frozen Shrikhand samples deposited at 5-7 ºC. Somewhat similar findings were also reported by Shekh et al., (2009) in market dahi, coliform counts in the present study were in close accordance with the counts with Karthikeyan (1993) and Salunke et. al. (2005). The coliform counts in product were in the range of 1.00 to3.10 c.f.u. x 102 /g. It is between the standard prescribed by IS (0.00 to 5.00 c.f.u./g) (Anonymous,2009). Low number of E. coli was found by Kumar and Prasad (2010) in Dahi sold in market.

Prabhakar Singh Maurya et al. (2019) reported that the Yeast and Mold count shows that, the highest mean count for yeast and mould in Apricot fruit Shrikhand (8.20) was obtained from the treatment T3 followed by T2 (7.20), T1 (7.00) and the minimum score (6.20) was obtained in T0 (control). There were significant differences found among the treatments. Akshay Prakashrao Deshmukh et al. (2025) reported that the Yeast and Molds content of various combinations of Chakka, Dragon Fruit, Sapota Fruit, and Rose powder of various treatments was 3.25 to 5.75 percent. The percentages of yeast and molds in the various treatments T0, T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, T13, T14, T15, and T16 were found to be 3.55, 3.25, 4.00, 4.05, 5.05, 4.75, 3.75, 4.25, 5.50, 5.75, 4.25, 5.50, 5.75, 5.25, 5.00, 5.75, and 5.75 percent, respectively.

Yeast and mould may enter milk products during the manufacturing process or afterward by improper handling. The yeast and mould of fresh Shrikhand was 4.25 x 104 cfu/ml. The yeast and mould count decreased up to 7 days during storage at 5-7 ºC temperature but it increased after 7 days. Whereas the yeast and mould count of Shrikhand stored at 5-7 ºC was 4.25 x 104 cfu/ml on first day and it increased to 5.50 x 104 cfu/ml on 7th day making the product acceptable. (Shimar Mishra et al., 2022).

The mean yeast and mould count of control shrikhand (C) were 1.05±0.05, 1.36±0.04, 1.52±0.04 and 1.58±0.04 log cfu/g for 1st, 5th, 10th and 15th days of storage respectively. The corresponding values for 0.025 per cent stevia added shrikhand (T1) were 1.25±0.05, 1.39±0.04, 1.47±0.04 and 1.68±0.03 log cfu/g. The yeast and mould count of 0.05 per cent stevia added shrikhand (T2) were 1.06±0.17, 1.42±0.04, 1.47±0.04 and 1.65±0.02 log cfu/g for the same storage intervals. The values for 0.1 per cent stevia added shrikhand (T3) were 1.15±0.07, 1.42±0.04, 1.56±0.03 and 1.65±0.02 log cfu/g respectively during 1, 5,10 and 15 days of storage. (Reshma et al., 2018).

IV. ANTIOXIDANT ACTIVITY

The antioxidant defense systems have the ability to remove the reactive oxygen species through enzymatic antioxidants like superoxide dismutase and glutathione peroxidase and non enzymatic antioxidants such as proteins and peptides, vitamins, trace elements, coenzymes and cofactors. These defense systems are not always effective enough to totally prevent the damage, and therefore, food supplements containing antioxidants may be used to help the human to reduce oxidative damage (Kullisaar et al., 2003). Recently it has been described by few researchers that milk protein hydrolysates and peptides released after hydrolysis posses antioxidant activities. Nutritional antioxidants play an important role in cellular antioxidative defense mechanisms. Vitamin E and C, ß-carotenoids, selenium, copper and zinc are the major dietry factors with the ability to act as antioxidants (Capel, 1988). Among the protective endogenous factors the enzyme superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSHpx) comprise the prominant cellular antioxidant defense system. SOD, CAT GSHpx and GR (Glutathione Reductase) constitute mutually supportive team of defense against reactive oxygen species (ROS) and preventing lipid peroxidation (Eaton and Barnmler, 1999).

Servili et al. (2011) reported that the total phenolic content of functional milk beverages fortified with olive oil extracts ranged from 53.4- 172.5 mg/kg. In another study, jambolan powder products had a lower TPC and DPPH inhibitory activity than jambolan pulp products (Bezerra et al., 2015). The antioxidant activity of the yogurt samples incorporated with non-encapsulated and encapsulated olive leaf extract was considerably higherthan control yogurt (Tavakoli et al., 2018). Optimized shrikhand was investigated for antioxidant activity, phenolic content, sensory analysis, and texture analysis. The sample of shrikhand with 2% flaxseed oil (FSO) had highest values of DPPH inhibition (88.82%) and 2% flaxseed oil microcapsule (FSOM) had highest value of TPC (23.30 mg/g GA).

The ABTS radical scavenging activity was determined by decolourisation of ABTS solution (Re et al., 1999). Radical scavenging activity of fresh and dried lemon grass extracts against stable DPPH was determined spectrophotometrically (Mensor et al., 2001; Vyas, 2017). The anti-lipid peroxidation ability of different concentration of lemongrass water extracts employing chick liver homogenate was measured in terms of formation of thiobarbituric acid reacting substances (TBARS) (Ohkawa et al., 1979; Sivakumar et al., 2011; Saxena, et al., 2016). Nitric oxide scavenging potential of fresh and dried leaves of lemongrass tea was determined by the method (Shirwaikar et al., 2006).

V. CONCLUSION

Shrikhand is a traditional fermented dairy product valued for its nutritional quality and unique taste. The incorporation of Cymbopogon citratus (lemongrass) and Nigella sativa enhances the functional properties of shrikhand by improving its physicochemical characteristics, microbial stability, and antioxidant potential. The presence of bioactive compounds such as phenolics, flavonoids and thymoquinone contributes to increased antioxidant activity and natural antimicrobial effects. Therefore, herbal enriched shrikhand can be considered a promising functional dairy product with improved health benefits and good quality attributes.

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