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Quality characteristics of breakfast cereals enriched with betel leaves extract: A review

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Abstract
Many studies have looked into the medicinal, nutritional, and other properties of betel leaves, but no studies are done to include them into daily meals to reap the advantages. It's commonly used as paan in most Asian nations, which isn't great for your diet, but you may take it to obtain its nutritional and medicinal worth by adding to your diet. Betel extract is added to cereal grain like oats and wheat to help prevent heart disease, cancer, and vitamin shortage, as well as improve preservation characteristics.

Keywords: Antioxidant, phytonutrients, polyphenols, cereals, breakfast

1. Introduction
Piper betel, a member of the piperaceae family, is a valuable medicinal herb found in Malaysia's central and eastern regions. In India, it's known as Paan, and it's second only to tea and coffee in terms of daily consumption. Despite its strangeness, the plant has long been more popular in India than in any other place in the globe. The countless quotations found in ancient literature, notably the Indian scriptures, attest to this (Rekha *et al.*, 2014) [78]. Betel leaves are very nutritive and contain substantial number of vitamins and minerals (Fazal *et al.*, 2014) [32]. The leaves also contain diastase and catalase enzymes, as well as a considerable number of important amino acids such as lysine, histidine, and arginine (Salleh *et al.*, 2015 and Jaiswal *et al.*, 2014) [52, 82]. The majority of prior Betel leaf research has focused on the components found in betel leaf extract (Jayalakshmi *et al.*, 2015 and Rintu *et al.*, 2015) [13, 26]. In order to collect medicinal components for further processing in pharmaceutical businesses, an appropriate extraction technique along with the optimization of the parameters involved in extraction and the use of the appropriate optimization approach is required. Scientific study on betel leaf demonstrates that it has a wide range of positive bioactivities, and its extract has a lot of promise for commercial product development (Anugrahwati *et al.*, 2016 and Ghali *et al.*, 2016) [53, 104]. Deep green heart shaped variegated leaves of the Piper betel or Betel vine are rich in nutrients, minerals, vitamins, antioxidants, and phytochemicals. The vine is a shade-loving perennial root climber that is dioecious (male and female plants are distinct) (Dwivedi and Tripathi 2014) [30].

The betel leaf is a creeper with glossy heart-shaped and white catkins that is evergreen and permanent. Piper (Piperaceae) is mostly found in tropical and subtropical climates across the world. Piper betel is grown in India, Sri Lanka, Malaysia, Indonesia, the Philippines, and East Africa, among other places. It has a strong flavour and a pale yellow fragrant essential oil. There are around 90 types of betel vine worldwide, with roughly 45 varieties found in India and 30 varieties in West Bengal (Jagdish 2015) [17].

The addition of plant-derived components and extracts to cereal-based diets has been recommended in study as a way to boost bioactive compounds and dietary fiber content (Perumalla and Hettiarachchy, 2011) [66]. Despite the emergence of many other food items, cereal grains and their refined meals continue to be the primary sources of human nourishment, particularly in poor nations. A vast variety of formulated cereals and cereal-based snacks are available in today's marketplace. However, some epidemiological studies have found a link between whole cereal grain consumption and a decreased risk of chronic illnesses including cancer, cardiovascular disease, and type 2 diabetes and gastrointestinal disorders (Fardet *et al.*, 2010) [33]. The health advantages of whole cereal grain may be attributable to the synergistic action of micronutrients and phytochemicals such as phenolic acids, sterols, tocols, tannins, and anthocyanins, as well as dietary fiber, which are commonly found in the outer bran layer and the germ.

Antioxidant qualities of phytochemicals included in cereal grains protect cellular components including membranes, proteins, and nucleic acids against oxidative damage, reducing cell death and hence the symptoms of ageing and aging-related disorders (Zhu *et al.,* 2013) [44]. Several scientific studies have found that dietary fiber aids in the prevention of certain illnesses and enhances the nutritional and technical properties of cereal and cereal-based dishes. Many extracts and substances from diverse plant sources have been recommended as supplements to increase the bioactive chemicals and dietary fiber content of cereal-based diets (Foschia *et al.,* 2013) [34].

Arani Datta *et al.,* (2011) [11] found that Phytochemical analysis revealed that the betel leaf powder included starch, protein, polyphenolic compounds, flavonoid, alkaloids, and complete antioxidant. The DPPH model revealed that the ethanol extract had significant free radical scavenging activity. The extract demonstrated strong antimicrobial activity against all of the examined bacterial strains. The extract's effect was nearly proportional to the concentration of the extract measured (Shreya *et al.,* 2011) [11]. Piper betel crude ethanol extract demonstrated potent antimicrobial activity against the pathogenic bacterial strains tested. The findings also suggest that scientific studies that typically use herbs with conventional claims of efficacy can yield fruitful results (Fazal 2014) [32].

Betel leaf (Piper betle L.) is a commercial crop that has been used in Southeast Asia as a mouth freshener and restorative in its raw form since ancient times. It possesses antibacterial, antioxidant, anti-diabetic, anti-carcinogenic, and other medicinal and functional properties. The leaf contains essential oil, which adds flavour and fragrance to the dish by emitting a distinct scent (Roy and Guha 2021) [79]. Estragole, chavicol, chavibetol, ß-cubebene, and caryophyllene are among the key components of this essential oil, which is a blend of concentrated phytochemicals. Betel leaf extracts or essential oil have been documented in several scientific studies for their multiple advantageous functional qualities, which are attributed to these bioactive components. When the leaf is ingested with areca nut and tobacco, however, some health risks may arise (Roy and Guha 2021) [79].

The leaves, along with the areca nut (which is often incorrectly referred to as "betelnut") and mineral slaked lime, are chewed together in a wrapped package (calcium hydroxide) (Umekar *et al.,* 2019) [76]. Catechu, also known as Kattha in Hindi, and other flavourings and spices may be added. The lime maintains the active ingredient's freebase state (Trivedi *et al.,* 2019) [76].

A quid is made from green or decolorized betel leaf and a variety of other ingredients, including slaked lime, areca nut chips, catechu, aniseed, clove, sweeteners, and tobacco, among others. Chewing the quid provides invigorating, mouth-freshening, and digestive benefits (Garg *et al.,* 2016) [91].

Anti-allergic, anticancer, insecticidal, antibacterial, and antioxidant properties are largely found in betel essential oils (Seow *et al.,* 2014) [88], indicating that these oils are natural food preservatives in high demand. The development of an alternative food preservative to prevent microbial spoiling is necessitated by the growing customer desire for natural products (Mandal *et al.,* 2014 and Roy *et al.,* 2016) [80], without causing any harm to one's health These oils present in betel, in addition to being potential natural food preservatives, may have a future in the creative food packaging industry due to their antibacterial and antioxidant properties (Asbahani *et al.,* 2015) [12], Aside from being a prospective and appealing flavouring ingredient for the food and beverage sectors.

South and Southeast Asia are the origins of the betel plant. With glossy heart-shaped leaves and white catkin, the betel plant is an evergreen and perennial creeper. Chewing betel leaves is regarded an edible digestive aid because of its intestinal, carminative, anti-flatulent, and gastro-protective characteristics (Mani *et al.,* 2017) [99]. Betel leaves have a taste that is both warm and spicy. It contains therapeutic properties that help to reduce coughs, irritation, nasal bleeding, and itching. It is the most effective treatment for dental caries and bacterial infections in the mouth. It stimulates the central nervous system, the intellect, enhances peristalsis, activates spasms, and relieves the snoring tendency (Vanitha *et al.,* 2017) [99].

2. History of betel leaf utilization

In India, the betel vine has been grown for its leaf from time immemorial, but only in the last 20- 25 years has it been commercially relevant. The fact that it is consumed by roughly 15-20 million people and may offer direct or indirect job possibilities for over 20 million people in India demonstrates the tremendous economic potential of betel growing (Kathirvel 2016) [59].

Piper betel (also known as Paan) leaves have long been used in Indian traditional medicine for its antioxidant and antibacterial qualities. The antibacterial activity of an ethanol extract of Piper betel leaves was tested against human pathogenic microorganisms in this study (both gram-positive and gram-negative) (Shreya *et al.,* 2011) [11]. Phytochemical analysis revealed that the leaf powder contains glucose, protein, polyphenolic chemicals, flavonoid, alkaloids, and total antioxidant. According to the DPPH model, the ethanol extract has a high level of free radical scavenging activity (Mukesh *et al.,* 2011) [11]. All of the bacterial strains examined showed considerable antibiotic activity in the extract. The extract's impact was nearly proportionate to the concentration of the extract in question (Arani *et al.,* 2011) [11].

Piper betle L., a member of the Piperaceae family, is a traditional herbal medicinal plant used in Asian nations for a variety of health advantages (Guha *et al.,* 2020) [55]. It's used in various products, such as herbal pharmaceuticals, medicines, and natural herbal formulations, are now in high demand. Betel leaves and their compounds have long been used to cure a variety of ailments, including foul breath, wounds, bruises, inflammations, cold cough, indigestion, and more (Nag *et al.,* 2020) [55]. Until recently, a wide spectrum of bioactive chemicals, such as polyphenols and terpenes, have been studied (Madhumita *et al.,* 2020) [55].

Betel leaves are the most well-known plant portion, and they have medical, religious, and ceremonial significance in Southeast Asia. It's commonly used as a mouth freshener, but it's also a significant source of unique therapeutical and medical value. (Vijayanchali 2018) [103].

Over 700 species can be found in both hemispheres, with about 30 species native to India (Bajpai 2010) [14]. It is grown on over 55,000 hectares in India, with an annual production of around Rs. 9000 million. West Bengal, with around 2000 hectares of land, contributes about 66 percent of total production. Simple, alternate, ovate, cordate, acuminate or acute, whole, bright green leaves are simple, alternate, lobed,

cordate, acuminate or acute. Piper betel is yellowish green to dark green in colour. Due to the inclusion of essential oils, it has a variety of flavours ranging from sweet to spicy. There are many different types of betel leaf, each with its own colour, size, flavour, and aroma. Magadhi, Venmony, Mysore, Salem, Calcatta, Banarasi Kauri, Ghanagete, and Baerhati are the Indian states of Magadhi, Venmony, Mysore, Salem, Calcatta, Banarasi Kauri, Ghanagete, and Baerhati. The gathered leaves are divided into several categories based on their size, color, and texture, as well as their maturity level (100 number per bundle) (Kumar 2010) [49].

Except for the drier north-western portions of India, betel vines (typically male plants) are grown all across the country. Regardless, the vines are grown for the purpose of collecting the heart-shaped green leaves. It thrives in the shady, tropical forest ecological parameters of 2250-4750 mm of annual rainfall, relative humidity of 40-80%, and temperatures of 15-40°C, respectively. Its cultivation requires a well-drained rich sandy or sandy loam or sandy clay soil with a pH range of 5.6–8.2 (Banu *et al.*, 2019) [71]. The crop is farmed with minor and frequent irrigations in places with lesser rainfall (1500-1700 mm). All agronomic needs, however, may differ from location to area, variety to variety, season to season, and owing to a number of other circumstances, but scientific data on these characteristics is limited. Because the leaves mature in 15-30 days, 1-4 harvestings are usually done once a month. Surprisingly, a decent crop yields roughly 60-70 leaves per plant and 6-7 million leaves per hectare every year (Princy *et al.*, 2019) [71].

It adds to the nation's foreign exchange revenues in addition to creating jobs. Betel leaves have a high export potential, making them the most promising commercial leafy crop for bringing in significant foreign cash. Betel leaf is frequently utilised in social, cultural, and religious occasions, in addition to having substantial therapeutic and nutritional advantages (Sripradha 2014) [81].

Fig 1: Uses of betel leaves

2.1 Pharmacological Activity of Betel Leaves

In several countries, a vast number of natural ingredients are utilized in traditional medicine to treat a variety of disorders. The Piperaceae family has around 2000 species, including Piper betel. Piper betel leaves have been demonstrated to be beneficial against a variety of human infections, while the processes are unknown. Piper betel extracts have been used for the treatment of numerous disorders for centuries due to its important qualities such as anti-oxidant, anti-cancer, anti-allergic, *etc*. (Rai *et al.*, 2019) [74].

2.1.1 Antioxidant activity

Antioxidant-rich foods assist to neutralize free radicals in the body, which helps to avoid or postpone oxidative damage to lipids, proteins, and nucleic acids (Devasagayam *et al.*, 2004) [29]. Antioxidants have been found to lower cardiovascular disease mortality and protect against cancer and other chronic diseases (Agoramoorthy *et al.*, 2008 and Sazwi 2013) [3, 86]. To protect against free radical-induced damage, mutagenesis, and carcinogenesis, eukaryotic cells have antioxidant molecules like glutathione, vitamin E (-tocopherol), vitamin A (retinol), vitamin C (ascorbic acid), carotenoids thioredoxin, lipoic acid, and ubiquinol, as well as antioxidant enzymes like SOD, GPx, and catalase (Maisuthisaku 2007) [56]. Many scientists have investigated the antioxidant properties of Piper betel L. extracts using various solvents and extraction durations (Alam *et al.*, 2012 and Aliahmat *et al.*, 2012) [6, 8].

The Folin-Ciocalteu procedure was used to determine total phenolic content. The polarity of the plant extract from various solvents was determined using High Performance Liquid Chromatography to determine the oil-water partition coefficient (HPLC). Because of their high oil-water partition coefficient, piper betel leaf phenolics were shown to be less polar than other phenolic antioxidants. For the manufacture of betel leaf extract for use as a natural antioxidant, the extraction solvent and duration are critical, according to the experiment. Chakraborty and Shah (2011) [22] tested four different extracts of Piper betel leaves (water, methanol, ethyl acetate, and petroleum ether) against four pathogenic bacteria: Streptococcus pyogenes, Staphylococcus aureus, Proteus vulgaris, and Escherichia coli. These extracts also yielded a number of known and undiscovered metabolites. Different analytical techniques such as NMR, Mass, and IR spectroscopy were used to do structural analysis. The TBARS and DPPH methods were used to conduct anti-oxidative tests. Rathee *et al.*, (2006) found that Piper betel leaf extract and its components have antioxidant activity. The 1,1-diphenyl-2-picrylhydrazyl (DPPH) experiment of ethanol extracts of three Piper betel varieties (Bangla, Sweet, and Mysore) demonstrated that the Bangla variety has the best antioxidant activity, which can be linked to total phenolic content and reducing capabilities of the extracts. The extraction of chavibetol (CHV), allyl pyrocatechol (APC), and their corresponding glucosides from the extract of the bangla variety was achieved by column chromatography. The chemical characteristics of three Piper betel types were found to be identical in HPTLC analysis of the extracts (Rathee *et al.*, 2006) [77].

2.1.2 Wound healing

In experimental wistar rats, the wound healing ability of Piper betle leaves and stem extract was examined. The interruption

of normal anatomic structure and function was referred to as a wound. Wound healing is a multi-step, multi-factor process that involves a number of cellular and metabolic processes. The results demonstrated that using an ointment formulation comprising Piper betle leaves and stem extract expedited wound healing and repair, which was highlighted by a full thickness coverage of the wound region by an ordered epidermis. When compared to the diseased group and the control group, the male albino rats treated with an ointment formulation containing 10% Piper betle leaves and stem showed substantial results (Nilugal *et al.*, 2014) [63].

2.1.3 Anticancer activity

Many human diseases, including cancer and tumours, are caused by persistent inflammation, according to laboratory and clinical investigations (Kangralkar 2013) [45]. The betel leaf has long been used as a home treatment for oral discomfort. Oral cancer was one of the top ten most prevalent cancers, with approximately 90% of cases reported from Southeast Asia, where tobacco chewing and smoking are common behaviours. Between two dietary interventions, the combination of betel leaf extract and turmeric was also found to be helpful. In breast cancer cell lines, the anticancer and free radical scavenging potential of Catharanthus roseus, Dendrophthoe pentandra, Piper betel, and Curcuma manga extracts was examined (Widowati 2013) [105]. Piper betel has been shown to have anti-cancer properties (Rai *et al.*, 2011) [75]. In mice, supplementing drinking water with betel leaf extract dramatically reduced benzo (a) pyrene-induced forestomach neoplasia in a concentration-dependent manner. As a result, Piper betel leaf extracts have antiproliferative and chemo preventive properties and can be utilized to treat a variety of maladies, including human lung cancer (Banerjee 2014) (15).

2.1.4 Anti-allergic activity

Wirotesangthong *et al.*, (2008) [106] investigated the effects of Piper betel on allergy mediator generation by bone marrow-derived cells and lung epithelial cells. Piper betel may offer a new therapeutic method for the control of allergic illnesses by inhibiting the synthesis of allergic mediators, according to the findings. An antiseptic's purpose was to diminish or eliminate the quantity of germs in the surgical field at the time of surgery. Amalia *et al.*, (2009) [9] investigated the Piper betel leaf and found it to be effective in cataract patients prior to surgery. To test the antihistaminic effect of Piper leaf extract, Hajare *et al.*, (2011) [39] used guinea pigs.

2.1.5 Anti-filarial activity

The anti-filarial activity of Piper betel was examined by Singh *et al.*, (2009) [95]. Piper betel L. n-hexane and chloroform fractions trigger various arms of immunological responses in BALB/c mice and have ant filarial efficacy against human lymphatic filarid Brugia malayi, according to the study.

2.1.6 Antibacterial activity

The medicinal plants' antibacterial effects have been documented all over the world, and they've been used to cure a variety of disorders including malaria, AIDS, and sexually transmitted diseases (Kumar *et al.*, 2010) [50]. The antibacterial action of Piper betel L. crude aqueous extract against Streptococcus mutans was reported (Nalina *et al.*, 2007) (60). The ultrastructure and acid-producing characteristics of Streptococcus mutans are the focus of antibacterial actions. According to transmission electron micrographs, the crude extract of Piper betel L. leaves damages plasma cell membranes and causes nucleoid coagulation. The extract was discovered to dramatically impair the bacteria's acid-producing abilities and to alter the ultrastructure of Streptococcus mutans. Antimicrobial activity also explained by Khan and Kumar (2011) [51] and Ghosh *et al.*, (2014) [36].

The antibacterial properties of the medicinal plants have been documented all over the world, and they've been used to treat a wide range of ailments, including malaria, AIDS, and sexually transmitted infections (Kumar *et al.*, 2010) [49]. Nalina *et al.*, (2007) [60] reported on the antibacterial activity of Piper betel L. crude aqueous extract against Streptococcus mutans. Antibacterial activities are focused on Streptococcus mutans' ultrastructure and acid-producing properties. The crude extract of Piper betel L. leaves disrupts plasma cell membranes and produces nucleoid coagulation, according to transmission electron micrographs. The extract was found to significantly reduce the bacteria's ability to produce acid and alter the ultrastructure of Streptococcus mutans (Caburian 2010) [20].

Kumar *et al.*, (2010) [51] investigated the antibacterial activity of Datura stramonium and Piper betle plant leaves, as well as the quantitative determination of protein. Datura and Piper betle, medicinal plants, were examined for antibacterial efficacy against three standard pathogens taken from Chandigarh: E. coli, Bacillus amyloliquefaciens, and Pseudomonas aeruginosa. Piper betle was one of the medicinal herbs evaluated in that study, and it exhibited promising antibacterial properties. Piper betle had no antibacterial effect against Pseudomonas aeruginosa, according to the findings. Shameem (2013) [92] reported on the chemical composition and antibacterial efficacy of the Vellaikodi type of Piper betle leaf oil against dental infections.

Agarwal *et al.*, (2012) [2] investigated and reported on four types of paan (Desawari, Desi, Bangladeshi, and Jaleswar). The results showed that cold aqueous, methanolic, ethanolic, and ethyl acetate extracts of dried leaves of all four varieties of Piper betle were tested against pathogenic microorganisms like Pseudomonas aeruginosa, Staphylococcus aureus, and Escherichia coli using the agar well diffusion method against pathogenic microorganisms like Pseudomonas Antimicrobial screening on Piper betel leaves was also discussed.

Subashkumar *et al.*, (2013) [97] investigated the antibacterial activity of Piper betel crude aqueous extract against harmful microorganisms. Piper betel extracts were found to be effective against the majority of bacteria species tested. The extract obtained from ethanol extraction showed the largest zone of inhibition against gram positive and gram-negative bacteria among the clinical strains examined. Only Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus aureus had the highest bacterial activity. It was suggested that pan extracts be utilized to treat a variety of clinical illnesses.

Fresh Piper betel leaves have antimicrobial properties. The disc diffusion method was used to test the antimicrobial activity of successive extracts of fresh pan leaves against both gram positive and gram-negative bacterial strains. They came to the conclusion that all extracts inhibited S. aureus effectively. When compared to normal penicillin, ether extracts were quite efficient. In comparison to normal

penicillin, aqueous extract was found to be highly effective against Bacillus and Pseudomonas aeruginosa (Shukla 2007) [93].

2.1.7 Antifungal study

Ali *et al.*, (2010) [7] investigated the antifungal activity of hydroxychavicol, which was obtained from the chloroform extraction of the aqueous leaf extract of Piper betel L., using 124 strains of fungi. The antifungal properties of Malaysian plants were assessed *in vitro* (Nazmul *et al.*, 2013) [61]. According to the findings, Piper betel gave the best antifungal susceptibility test results, demonstrating antifungal activity against four out of five fungus types. To obtain first separation of active antifungal component in the form of methanol fractions, the Solid Phase Extraction (SEP) approach was used on Piper betel. As a result, Piper betle was found to have the most antifungal activity against Trichophyton rubrum (Salmah 2011) [62].

2.1.8 Oral hygiene

Bissa *et al.*, 2007 [18] looked into oral hygiene and found that the combination of betel leaf, cardamom, and clove had a synergistic effect on the oral bacteria population. The usual oral commensally flora created a chronic endogenous infection in dental caries. Streptococcus mutans is the bacteria most responsible for dental decay in humans. Mutan, salivarius, anginosus, and mitis are the four species of streptococci. Lactobacillus acidophilus bacteria, in addition to Streptococcus mutans, are likely to play a minimal role in plaque acid formation. Varunkumar *et al.*, (2014) [100] evaluated the anticariogenic activity of crude extract of Piper by examining its effects on salivary pH. Chu (2001) [25] founded that the outcome of betel chewing on the central and autonomic nervous systems.

2.1.9 Anti-asthmatic effect

In guinea pigs, Misra *et al.*, (2014) [58] investigated the anti-asthmatic impact of Piper betle. Asthma is characterized by the tracheobronchial smooth muscle's hyperresponsiveness to a multitude of stimuli. Bronchial asthma was a disorder that was characterized by inflammation. Bronchial asthma may be caused by free radicals and superoxide (Darvhekar *et al.*, 2011) [27]. Bronchoconstriction can be caused by histamine. Piper betle extract can greatly lessen the effects of bronchial asthma, albeit its impact is smaller than that of di-phenyl hydramine. Other mediators, such as leukotriene, play a key role in asthma in humans. Thus, the effect of Piper betle L. on human asthma was unknown, but it was determined from that experiment that Piper betle may lessen bronchial asthma in guinea pigs (Rekha *et al.*, 2014 and Misra *et al.*, 2014) [78, 58].

2.1.10 Immunomodulatory Activity

The immunomodulatory effect of a methanolic extract of Piper betel was investigated by Kanjwani *et al.*, (2008) [46]. A mixture of phenols, flavonoids, tannins, and polysaccharides made up the MPb. The study included both *in-vitro* and *in-vivo* testing. MPB's effects on lymphocyte proliferation, interferon receptors, and nitric oxide generation were studied *in vitro*.

In addition, mice immunized with sheep red blood cells were investigated *in vivo* for humoral and cellular immunological responses to the extract at various dose levels. P. betel inhibited phytohaemagglutinin-stimulated lymphocyte proliferation in the peripheral blood in a dose-dependent manner. The extract may have an immunosuppressive effect on the cellular and humoral responses in mice, as evidenced by the decrease in antibody titre and greater suppression of inflammation. As a result, the MPB might be thoroughly investigated as a therapeutic agent for a variety of immunological illnesses, including autoimmune diseases (Marathe *et al.*, 2008) [46].

Betel leaves are used in India for a number of medical and health purposes. In Indian folk medicine, betel leaf is used as an antiseptic and is commonly applied to wounds and sores for its healing effects. Additional research has showed that paan extract possesses antibacterial and antileshmian properties as a result of this characteristic (Sarker *et al.*, 2008).

The fresh juice of betel leaves is used in several ayurvedic treatments. Betel leaves have long been studied for their pharmacological effects.

Table 1: Ayurvedic benefits of betel leaves

Symptoms	Remedy using betel leaves
Scanty or Obstructed Urination	The juice of betel leaves is said to have diuretic qualities. Its juice, when blended with weak milk and moderately sweetened, aids in the transit of urine.
Weakness of Nerves	The use of betel leaves in the treatment of neurological illnesses is useful. A tonic made from the juice of a few betel leaves and a spoonful of honey is effective. You can take a spoonful of this combination twice a day.
Headaches	The analgesic and cooling qualities of the betel leaf are well-known. It can be used to treat severe headaches.
Respiratory Disorder	Betel leaves can help with pulmonary problems in children and the elderly. To ease a cough or trouble breathing, soak the leaves in mustard oil and warm them before applying to the chest.
Constipation	A suppository composed of the stem of betel leaf bathed in castor oil can be inserted into the rectum in the event of constipation in youngsters. This helps constipation right away.
Sore Throats	The leaves can be used locally to relieve a sore throat. Honey should be added to the crushed fruit or berry. Taken to get rid of a nagging cough
Wounds	Wounds can be treated using betel leaves. Extract the juice from a few leaves and apply it to the wound. Then it should be wrapped in a betel leaf and bandaged. Within two days, the wound will heal with just one treatment.
Boils	The herb can also be used to treat boils. A leaf is slowly warmed until it softens, then a coating of castor oil is applied. The oiled leaf is placed on top of the inflamed area. Every several hours, this leaf must be replaced. The boil will explode after a few applications, emptying all of the purulent stuff. The application can be submitted at night and deleted the following morning.

Despite its foreign origins, the betel vine is far more popular in India than in any other country in the world. A well-prepared betel quid is still regarded as an excellent mouth freshener and mild vitalizer, and is routinely served on social,

cultural, and religious occasions such as marriage, Puja (religious festivals), and Sraddha ceremony (religious function performed after cremation) (Trivedi *et al.*, 2019) [74].

Table 2: Proximate composition of dehydrated betel leaves powder (Per 100g dry weight)

Nutrients	Content
Moisture (%)	12.66
Protein (g)	12.07
Fat (g)	4.62
Total ash (g)	15.33
Crude fibre (g)	6.5
Carbohydrate (g)	48.82
Energy (Kcal)	285.14
Vitamins	
β – carotene (µg)	6693
Vitamin C (mg)	32.86

***Source*:** Vernekar, 2019 [102]

Piper betel is a perennial and evergreen plant that God created and gave the form of his own heart to Betel leaf is known by its Vedic name Saptasira in Ayurveda (Indian medical system) and is used as an adjuvant with many treatments for voice, blood purification, laxative, and appetiser (Kiran *et al.*, 2018) [4]. Ascorbic acid is a good antioxidant that aids in the reduction of free radicals in the body, hence avoiding cancer. Betel leaf, in addition to being used as a mouth freshener, offers a number of health advantages that make it suitable for pregnant women (Agrahari *et al.*, 2018) [4].

3. Betel Leaf: A Healthy Underutilized Herb

The leaves of Piper betel are deep green, heart-shaped, and have a pale-yellow aromatic essential oil with a harsh burning taste. Piper betel vines are native to Malaysia (Chauhan 2011) [24].

Betel leaf, a member of the Piperaceae family, is said to have over 100 variants worldwide, with roughly 40 of them found in India. It thrives on arid, loam, and clay soils with high detritus content and a pH of 7-7.5. These leaves are fragrant due to the presence of essential oils, and their flavour ranges from sweet to spicy (Pradhan *et al.*, 2013) [69].

The most valuable part of the plant, the betel leaves, contain tannins, chavicol, phenyl, propane, sesquiterpene, cyneole, alkaloid, sugar, and some essential oil, and have been found to have a variety of medicinal properties, including digestive, appetizer, aromatic, expectorant, stimulant, antibacterial, euphoria-inducing, antiprotozoal, carminative, anti-fungal etc. (Bajpai 2010) [14].

Fig 2: Heart shaped betel patterns

Table 3: Taxonomical classification of betel plant

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnolipsida
Order	Piperales
Family	Piperaceae
Genus	Piper
Species	Betel

The leaves of the betel plant are used for a variety of purposes, although the leaves are the most prevalent. The leaves have an antibacterial function, which can help to keep infections from getting into your diet (Mazumder *et al.*, 2016) [57]. Betel leaves have been shown to have antibacterial action against Streptococcus pyogenes, Staphylococcus aureus, E. coli, Pseudomonas aeruginosa, and other bacteria. Enterococcus faecalis, Citrobacter koseri, Citrobacter freundii, Klebsiella pneumoniae, and other harmful bacteria were all killed by the leaf extract (Chakraborty *et al.*, 2011) [22].

The scent of betel leaf is enhanced by the presence of essential oils comprising phenols and terpenes. Antioxidants are chemicals that inhibit the oxidation of other compounds in the presence of oxygen or reactive oxygen species in the atmosphere. The amount of physiologically active chemicals in betel leaves varies by plant variety, season, and location (Gargh *et al.*, 2016). The numerous antioxidants and phytochemicals existing in the betel plants are chavibetol, chavicol, hydroxychavicol, estragole, eugenol, methyl eugenol, hydroxy catechol, caryophyllene, eugenol, methyl ether, γ-lactone, allyl catechol, cepharadione, dotriacontanoic acid, tritriacontane, p-cymene, terpinene, eucalyptol, carvacrol, sesquiterpenes, cadinene, hentriacontane, pentatriacontane, stearic acid, n-triacontanol, triotnacontane, piper longuminine, allyl pyrocatechol diacetate, isoeugenol, 1, 8-cineol, α-pinene, β-pinene, sitosterol, β-sitosteryl palmitate, γ-sitosterol, stigmasterol, ursolic acid and ursolic acid 3β-acetate (Shah *et al.*, 2016) [91].

Table 4: Organoleptic/Macroscopic characteristics of leaves of Piper betel L

Sr. No.	Parameters	Observation of Leaf
1	Color	Yellowish Green -Dark Green
2	Shape	Heart shape
3	Taste	Sweet to Pungent
4	Texture	Glossy, smooth
5	Apex	Pointed
6	Venation	Reticulate
7	Odor	Characteristic and pleasant

***Source*:** Agrahari 2018 [4]

In research, betel extract has been proven to reduce the weights of reproductive organs, blood hormone levels, fertility, and serum glucose levels (Priya *et al.*, 2012) [72]. Diabetes is a metabolic disorder marked by high blood sugar levels, which are aggravated by insulin shortage in glucose, lipid, and protein metabolism (Balan *et al.*, 2014) [54]. As a result, the body's cells are unable to effectively respond to insulin. The administration of betel leaf to diabetic rats has also been reported, with the findings that glucose-6-phosphatase and fructose-1,6-isophosphatase levels in the liver decrease with an increase in hexokinase levels (Madan *et al.*, 2014) [54]. Antioxidant, anti-diabetic, gastroprotective,

anti-nociceptive, insecticidal, and other biological actions of betel leaf have also been documented (Srinivasan *et al.*, 2016) [96].

Betel leaves are known as "Paan" in India. During supper, betel leaves are sometimes used as a mouth refresher (Tiwari *et al.*, 2016) [5]. Betel leaves have long been utilised in Indian folk medicine for their therapeutic benefits. In ancient India, betel leaves were considered auspicious and are still utilised in religious events today (Chauhan *et al.*, 2016) [5]. It can be used to treat hypertension, diabetes, brain poison, boils and abscesses, headache, leucorrhoea, wounds and bruises, ringworm infestation, speech difficulties, rheumatism, wound recovery, obesity, conjunctivitis, constipation, abrasion, and other conditions (Aishwarya *et al.*, 2016) [5]. As a powerful antioxidant, ascorbic acid aids in the reduction of free radicals in the body, which helps to prevent cancer. Gastroprotective properties of betel leaf extracts aid to prevent stomach ulcers (Rai *et al.*, 2011) [75].

Betel leaves are also frequently used as a mouth freshener in India and other Southeast Asian countries to prevent dental caries. Phenolics, which are aromatic benzene ring compounds with one or more hydroxyl groups and their derivatives produced by plants, are found in high amounts in betel leaves (Shagirtha *et al.*, 2012) [68]. Phenolics, secondary natural metabolites of plants, are aromatic benzene ring compounds with one or more hydroxyl groups and their derivatives produced by plants are used primarily for stress protection (Muthumani *et al.*, 2012) [68]. Piper betel leaf extract contains polyphenols, alkaloids, hormones, saponins, tannins, estragole, catechols, terpenes, limonene, and cadinene, among other bioactive compounds (Prabu *et al.*, 2012). Many therapeutic plants have lately been investigated for their chemical composition, antioxidant activity, and antibacterial properties (Bhat *et al.*, 2014) [32].

Table 5: Chemical constituents of piper betel leaf

Chemical constituents	Percentage of chemical constituents
Tannins	0.1-1.3
Chavibetol acetate	15.5
Caryophyllene	3.71
Safrole	48.7
Allyl pyrocatechol diacetate	0.71
Eugene	0.32
f-Pinene	0.21
1, 8-Cineol	0.04
Chavibetol methyl ether	0.48
Allyl pyrocatechol Monoacetate	0.23
a-Pinene	0.21

***Source*:** Rai 2019 [74].

Due to the time and financial limits imposed by new medication approvals during a pandemic, natural components must be used to save lives. Plants have been utilised as a source of medicine continuously owing to the existence of certain chemicals/active substances that indigenous people have empirically shown (Tallei *et al.*, 2021) [21]. Plants also contain active chemicals that have been shown to be effective in the treatment of a wide range of ailments, both infectious and metabolic. They are potential sources of new antiviral and immunomodulatory medicinal molecules (Chakraborty *et al.*, 2021) [21].

The presence of phenols and terpenes in essential oil gives the betel leaf its scent (EO). Several research have been carried out in order to uncover natural antioxidants that may be utilised to build new nutraceutical products. These items can help the body avoid oxidative damage (Nouri and Karim, 2014) [64].

Piper betel has been considered as a prospective source of natural antioxidants in a variety of applications, including medical, food, and pharmaceutical sectors, due to its potency (Venkadeswara *et al.*, 2014) [101]. The extract from the leaves can be utilised as a food preservative to ensure that key nutrients are delivered to consumers' diets (Putnik *et al.*, 2017) [73].

Despite the fact that leaves contain a variety of health benefits, there is a significant quantity of leaf waste every year, ranging from 35 to 70 percent, owing to storage, transportation, and perishability (Banerjee *et al.*, 2016) [57]. The purpose of this review is to concentrate on betel leaf manufacturing, waste management, and other positive benefits such as antibacterial, anti-cancerous, antioxidant, etc. (Mazumder *et al.*, 2016) [57]. As a result, it may be used to manufacture betel powder, which reduces waste and makes it more affordable.

3.2 Preparation of Betel Powder

Betel leaves are freshly harvested and dried for removing of moisture. Then its powdered Betel leaves are cleaned after the harvesting and then its washed in proper way to avoid contamination, then it's shredded into many pieces to increase the drying process, can be dried in natural (eg. sun drying) or mechanical (e.g., tray drying) ways, grinded and powdered for further process. From the botanical, export potential, economic status, pharmacological, chemical, and industrial applications points of view, it is clear that betel leaves are an important herbal cash crop.

The current study examines the drying kinetics and changes in quality of betel leaf paste during hot air drying for the production of betel leaf paste powder. The changes in numerous qualities, such as physio-chemical properties, proximate composition, and other functional properties, were evaluated in comparative research. The dried powders of betel leaf paste have a longer shelf life than the raw leaves. The samples were dried at three different temperatures, 50, 70, and 80 degrees Celsius, until they attained a consistent weight. The water activity of the samples dried at 80°C and 70°C was 0.1, while the sample dried at 50°C had the highest water activity of 0.15. Protein, fat, crude fibre, and ash content were found to be somewhat greater in betel leaf powder dried at 70 °C compared to other drying temperatures. This change in composition might be due to increased dry matter in dried powder, a shorter drying time for paste, and less nutritional.

Fig 3: Final betel leaf dried powder

3.3 Inclusion of Betel Extract to Breakfast Oats and Wheat

However, as the threat of synthetic medications and food additives such as preservatives, coloring agents, and antioxidants has grown, humanity has become more cognizant of natural resources and their advantages (Sarma *et al.*, 2018) [85]. Several studies are presently being conducted to investigate the nutraceutical, antimicrobial, and nutritional properties of natural herbs. Piper betle L., sometimes known as betel leaf, is one such important herb (Rasane *et al.*, 2018) [70]. Cereal grains are evolutionarily engineered to be chemically, mechanically, and biologically inert before the seed germinates into a new plant under the right conditions. Cereal grains are also an excellent biological tissue for the long-term preservation of essential micro- and macronutrients for both livestock and humans. Unprocessed cereal grains, on the other hand, are not easily digestible, but they must be refined to become a palatable and healthy meal (Giradet 2010) [37]. This is largely due to the fact that the seed's exterior component (the hull) is built to shield the seed from harsh conditions. The hulls are so powerful that if the seed is eaten raw, it will move through the entire digestive tract with little to no digestion, which is a plant reproduction technique to maximize seed dispersal (Fardet *et al.*, 2010) [33]. Milling and other processing steps are thus needed to turn the seed to food. The advancement in cereal processing has been critical in elevating cereal grains to the status of one of the world's most valuable foodstuffs. Oats have many distinct properties that distinguish them from other cereal grains when milled (Girardet *et al.*, 2010) [37].

Along with traditional flakes, directly expanded breakfast cereals are the most common form of breakfast food, particularly in Western countries (Sabikhi *et al.*, 2014) [47]. Wholegrain flour is a good source of dietary fiber, which helps to improve the role of the gastrointestinal tract and has an effect on the human cardiovascular system. Dietary fiber aids in the prevention of obesity and provides satiety filling (Kaur *et al.*, 2014). That is why new types of products, such as enriched breakfast cereals containing wholegrain flour, bran, or germs, are being created (Zainuddin *et al.*, 2014) [107].

In recent years, since they are high in the functional ingredient glucan, a bioactive component that has been marketed as a means of lowering serum and plasma cholesterol levels (Mweis *et al.*, 2010) [1]. Other bioactive components of oats, such as phenolic content and antioxidant compounds, can also play a role in the health benefits of oat-based breakfast cereals.

Oats (Avena sativa L.) have attracted a lot of attention due to their high levels of dietary fibre, phytochemicals, and nutritional value. Oats are thought to have a number of health benefits, including being hypocholesterolemic and anti-cancer. Oats have also recently been allowed for use in the diets of celiac disease patients. Because of their excellent nutritional value, oat-based foods such as breads, biscuits, cookies, probiotic drinks, morning cereals, flakes, and infant food are becoming increasingly popular. Oats and their products are being studied to see if they can help with a range of ailments (Prasad *et al.*, 2013) [70].

Oats have the additional benefit of not containing gluten because their storage proteins are avenins. As a result, they should be used in gluten-free diets aimed at coeliac patients because avenins are less likely to induce reactions even in coeliac patients (Zimmer 2011) [108]

Betel leaves can be used as an additional ingredient in morning cereals to improve the flavor and nutritional value. Because the oat groat is softer than other grains, such as wheat, and cannot be easily divided into germ, endosperm, and bran fractions, it is more commonly ingested whole (Basak 2018) [16].

Whole grains are believed to possess a variety of polyphenols and other antioxidant compounds that can act together to improve human health, Antioxidants, such as vitamins E and C, are believed to shield the body from free radical damage and can play a role in disease prevention. Polyphenols have traditionally been thought to be powerful antioxidants. Breakfast cereals made from oats have gained popularity (Fardet 2010) [33].

The outer layer of the groat is also extracted to form oat bran, which includes protein, neutral lipids, b-glucan, phenolics, and niacin (Devin *et al.*, 2014) [31]. The inner endosperm contains proteins, carbohydrates, and b-glucan, whereas the germ contains primarily lipids and proteins. These oat components, as well as their unique physiological structure, necessitate that they be treated differently than other grains, and they also provide them with certain nutritional qualities (Eric *et al.*, 2014) [31].

Because of their high number of dietary fibers, phytochemicals, and nutritional value, oats (*Avenaativa* L.) have received a lot of attention recently. Oats have a number of health benefits, including hypocholesterolemia and anti-cancer qualities. Only celiac patients' diets have been authorized for use with oatmeal (Unnikrishnan *et al.*, 2013) [70]. Because of their great nutritional content, oat-based foods such as toast, biscuits, cookies, probiotic drinks, morning cereals, flakes, and infant food are becoming increasingly popular. Oats and their products are being studied for their potential to help cure a variety of ailments (Rasane *et al.*, 2013) [70].

Wheat (*Triticum aestivum* L.) is one of the most widely farmed grains in the world, with fields stretching from Scandinavia to Argentina. The nutritional value of wheat grain, which is determined by grain bioactive components, dietary fibers, minerals, and vitamins, particularly B vitamins, are the most important aspects of wheat grain quality (Hussain *et al.*, 2012) [42], as well as its breadmaking qualities, which include milling, drying, and baking results (Espinosa *et al.*, 2018) [40]. The ability to produce specific food items, as well as their increased consumption as a result of industrialization and westernization, is driving growing worldwide demand for wheat. Wheat may be turned into bread, other baked items, noodles and pasta, and a range of useful substances thanks to the gluten protein portion in particular (Shewry *et al.*, 2015) [67].

The findings of (Nouri *et al.*, 2015) [65] clearly show that including betel leaf extract at various levels resulted in structural change of the noodles, resulting in a softer product when compared to the control. The extract-infused noodles, on the other hand, have higher product scores in all sensory aspects than the control. The extract at 15% gives the highest-quality product, allowing for the use of betel leaf polyphenols' favourable health effects.

Wheat is commonly thought of as primarily a source of energy (carbohydrate), which it is. However, it also contains significant amounts of other essential nutrients such as proteins and fiber, as well as minor components such as lipids, vitamins, minerals, and phytochemicals, all of which

can help you eat a healthier diet. For all age groups, cereals and breads were the leading sources of nutrients and non-starch polysaccharides (dietary fiber), with bread accounting for over a quarter of total daily consumption (Sandra *et al.*, 2015) [67]. Cereals, such as maize, provide a significant quantity of calcium, B vitamins, and iron in one's daily diet. Wheat's significant contributions to fundamental nutrients in the United Kingdom, a highly stable country with a diversified diet, underline its global importance in nutrition (not only in developing nations) (Peter *et al.*, 2015) [67].

Cereals offer 80 percent of energy and all other nutrients in India's rural poor's diets, with the exception of vitamins A and C. Cereals must be supplemented with other food categories such as pulses, vegetables, fruits, or animal products to make the diet more nutritious and adequate, notably in terms of vitamin A, iron, and riboflavin (Shewry *et al.*, 2015) [67].

Poor people's diets can be modified by substituting a cereal diet (such as rice) with mixed cereals, such as millets, lowering the prevalence of serious nutritional deficiencies (such as vitamin A insufficiency and iron deficiency anemia (Gopalan *et al.*, 2012) [38].

Betel leaves are blended with oats and wheat for maximum health advantages, operating as a flexible diet that prevents and improves a variety of ailments (Kang 2013) [44].

4. Conclusion

Future study should focus on the discovery of more bioactive chemicals due to the limited information available in the studied literature concentrating on suitable contemporary preservation procedures and phytochemical features of those treated betel leaves extract utilized as traditional medicine. Considering the biological properties stated above, such as antibacterial activity, antioxidant activity, antidiabetic, anticancer activity, and so on, it is clear that betel leaf has enormous potential as a future green medicine. Value addition to a cereal commodity that has been utilized in ordinary breakfasts throughout the world for a long time. The addition of betel extract to wheat and oats increases antibacterial action and provides the body with various minerals, including vitamin A and C. By doing so, we can avoid a lot of sicknesses and deficits. Various studies should conduct and implement in betel leaves to enrich the intake of nutrients. From the botanical, export potential, economic status, pharmacological, chemical, and industrial applications points of view, it is clear that betel leaves are an important herbal cash crop. This review research looked at the bioactivity, biological characteristics, and other aspects of betel leaf and its compounds. Betel leaf is high in phenolic compounds, which have a wide range of medicinal properties and are responsible for a variety of health advantages.

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