Microbial diversity of fermented foods.

Abstract

Fermentation is an age-old chemical process which plays a vital role in various aspects of foodprocessing all over the world and helps in enhancing flavour, value addition and provides many health benefits to the consumer. Fermentation has multi directional role and significance in foodprocessing. Over the years, research on fermentation has continued to advance, demonstrating its potential use in the production of pharmaceuticals, a wide variety of bio-based products, and sustainable biofuels. Fermentation has lately attracted renewed interest as sustainable agriculture and food production has become more and more important. There are variety of fermented products which are manufactured commercially and are being consumed by mass population due to their several beneficial health aspects. The process of fermentation includes various steps such as introduction to microbes, breakdown of sugar, maintenance of pH and enhancement of flavour. This review provides an information about various food products prepared by fermentation in food industries, their potential health benefits, value addition of raw materials and the science behind it. Although food was traditionally preserved by fermentation, this process is becoming increasingly popular today since it produces nutritious food items with benefits beyond just basic nutrition and flavour. Foods that have undergone fermentation increase the body's immunity against harmful bacterial infections and strengthen the immune system. During fermentation, a variety of biochemical changes take place that may have an impact on the nutritional components and, in turn, the end product's characteristics, such as digestibility and bioactivity.

Keywords: Fermentation, microorganism, probiotic, value addition,

Introduction

Fermentation is a fundamental chemical process that breaks down intricate materials into simpler onesusingthepowerfulactionsofmicroorganismsorenzymes.Thesemicroscopicbeingsefficientlyhandlethemetabolicaspectsoffermentation,anintegralpartofhumancivilizationwhichhasplayedapivotalrole for countless centuries. Its indispensability is showcased by its significant influence on variousfacets of our daily lives like the manufacture of sustenance and beverages, as well as ground-breakingdevelopments in biotech. Fermentation research has constantly evolved through theages, proving its potential utility in producing sustainable biofuels alongside drugs and diverse rangeof bio-based merchandise. Additionally, it occupies a crucial position in traditional food preservationtechniquesandflavourgeneration (Yu et al., 2010).Aswetakestridesintothe21stcentury,thereremainsacontinuedemphasisonexploringfermentation'sabilityinenhancingfoodsafety sustainability and wellness advantages (Ganzle, 2015). It acts as an essential metabolic methodforfermentingfood.Microscopicorganismsincludingbacteriayeastmouldconvertorganiccomponentsduringthiscomplexbiochemicalprocessinvolvingfermentation.Thesemicrobeworkhorsesutilizearangeofsubstratescomprisingsugarsyieldingvariedendproductssuchasalcoholorganicacidsgases.Often,thesefinalgoodsareaccompaniedwithanexpanseofsecond-genmetabolites. Globally,arangeoffermentedproductscarryingexclusivecharacteristics and cultural worth have been produced due to the variety of fermentation procedurespowered by a wide array of microorganisms (Tamang et al., 2016). As the importance of sustainableagriculture and food production grows, interest in fermentation has recently revived. Communitiesengaged in seeking more eco-friendly remedies for environmental issues have been attracted to theirabilitytoconvertagriculturalwasteintovaluablebio resourcessuchasbio fuelsandbio plastics. Theproductionofhigh-qualitysubstancesliketherapeuticproteins,enzymes, andbio active molecules has also gained from fermentation boosting innovation in the bio pharmaceuticaldomain. Theserevelationsenhancedourgrasponfundamentalmechanismsleadingto new food processing techniques like precision fermentation and functional foods creation. This comprehensive study is aimed at providing a current overview offermentation processes from historical roots to its diverse deployments in twenty-first century life. Inthis module, we will extensively discuss the fundamental chemical reactions, the role played bymicroscopic organisms and how fermentation impacts various food industries. Further, we will scrutinizerecent advances in fermentation technology alongside the hurdles and opportunities that still remainfor us to harnessthisage-old yetever-evolving biologicalprocessto its fullpotential (Marco et al., 2017).

Mechanismoffermentation

FermentationMechanisms:Peelingbackthesciencebehindbelovedproductssuchasyogurt,beer,and bread.

MicrobialMetabolism:Microbesformthebackboneoffermentationitself.Sugarsandorganicmolecules become the diet for bacteria and yeast, converting them into simpler components. With thismetabolic activity comes a range of by-products, effectively fueling bacteria. Byunderstandingmicrobialmetabolisminfermentation,industrieslikebio fuels,medicinaldrugs,andfoodproduction can gain a foothold. To make the most out of yields, quality control,and profitability during fermentation processes – it's crucial to grasp the intricate dimensions ofmicrobial metabolism. Glycolysis is one way where glucose changes into pyruvatewhile generating both ATP and NADH - an enduring process for fermentation.Alongsideglycolysisareothervitalpathwaysthatplayaroleinmicrobialmetabolismduringfermentation like - tricarboxylic acid cycle (TCA) or pentose phosphate path.Diverse Microbial Lifeforms Various microorganisms- bacteria, yeasts & moulds – are used infermentation processes due to their peculiar metabolic characteristics.For example,*Saccharomyces cerevisiae* or baker's yeast is renowned for its capability to generate ethanol- making itasignificantplayerinthebio ethanolindustry (Parapouliet al., 2020).

Anaerobic respiratory process: This is a fermentative activity that often takes place in the absence of oxygen. Insituations where oxygen is scarce, bacteria turn to fermentation instead of oxidative phosphorylation.Microorganisms must undertake this switch in metabolism to survive across a range of environments.Thesignificanceofresearchintoanaerobicrespirationandfermentationextendsbeyondjust biology to encompass the pharmaceutical sector as well. Penicillin is one among many antibioticsproduced through fungal and bacterial fermentation. Another vital formof anaerobic respiration is lactic acid fermentation which can often be observed in muscles duringintense physical exertion when there's limited oxygen supply. In this process glucose gets convertedintolacticacid causing musclediscomfortandfatigue(Baldwin and Haddad.,2019).

EthanolProductionandflavourdevelopment:*Saccharomycescerevisiae*,akindofyeast,iswellknownfor its function in alcoholic fermentation and the formation of flavour. Yeast converts carbohydratesinto ethanol and carbon dioxide throughout this process. Beer, wine, and other alcoholic drinks areproduced by this method (Krogerus et al., 2015). In addition to preservation, fermentation can alsoimprove flavour. The distinct flavour profiles of fermented foods and drinks are influenced by themetabolicbyproductsoffermentation,suchasalcohols,esters,andorganicacids(Bokulichand Bamforth.,2013).Baking also heavily relies on fermentation. When yeast breaks down glucose, carbon dioxide isreleased. This gas becomes trapped in the dough and causes it to rise. The airy and fluffy texture ofbreadis theresultofthis leavening process. LacticAcidFermentation:Thisisoneofthemostprevalentkindsoffermentation.Thisprocess,whichresultsinthedistinctivetanginessofyogurt,sauerkraut,andkimchi,involvesbacterialikeLactobacillusconverting carbohydrates into lactic acid (Ganzle, 2015). In the food business, lactic acid fermentationis also used to pickle vegetables in order to preserve them. The naturally occurring lactic acid bacteriaon vegetables break down carbohydrates into lactic acid, which creates an acidic environment thatpreventsthegrowthofmicrobesthatcausespoiling.Applicationsinbiotechnology:Beyondtheculinaryrealm,fermentationfindsapplicationsthatgobeyondfoodproduction. It has a pivotal role in creating bio fuels, enzymes, and crucial medicinal proteins.

Probiotic Manufacture: Probiotics are live microorganisms which provides health benefits to the hostwhenconsumedinadequateamount.Fermentationisfundamentaltoproducingfoodsrichinprobiotics,think yogurt and kefir. These edibles host advantageous bacteria which have been known to improvegut health while boosting overall wellness. The popularity of probiotics - livemicroorganismswhoseoralconsumptionislinkedwithdocumentedhealthbenefitsonlywheningestedinsizeablequantities-haswitnessedsubstantialgrowthowingtoitspotentialabilitytoenhancegeneralas well as gastrointestinal well-being. Probiotics helps in improving gut health andimmunesystem.Examplesforprobioticsareyogurt,kefir,kombucha,cheese,kimchi,misoandpickles (Marco et al., 2017).

Prebiotics:Thesearenon-digestiblefoodingredientswhichhelpsinthegrowthofbeneficialmicroorganisms. Forexample, onion,garlic,soyabeanand chicoryroot.

Food itemsproducedbyfermentation

Let's embark on a delectable journey encompassing an array of food creations nurtured by the processof fermentation, an enchanting world where flavours are as dynamic as they are bewildering, grantingyouaglimpse into theastoundingdiversity encapsulatedwithinglobalculinaryspectacles.

Kimchi-hailing from Korea and proudly regarded as their national delight, serves as the genesis forour adventure. Kimchi, a traditional lactic acid fermented vegetable product, is a staple of the Korean cuisine and is made by combining Chinese cabbage, radishes, fish sauce, spices, and other ingredients. After being fermented by a number of different microbes, the combination is subsequently eaten raw all over the world. The key players in its creation include Napa cabbage and radishes,these are complexlycombined with spicy chili peppers, garlic and ginger to manifest a piquant fermented veggie amalgamthat also has the additional perk of being rich in probiotics; wonderfully improving gut health whilstleavingyourpalatetruly mesmerized (Tamangetal., 2021).

Kombucha- It is a fizzy drink with a sweet taste made from bacteria, yeast, sugar and tea. It is a good source of probiotics. This tasty drink was originated in northeast China. The next destination in our adventure is China and Russia, where kombucha has gained awider reputation across the globe. Kombucha, a fizzy tea crafted by fermenting a mixture of yeast andbacteriacalledSCOBYisknownforitsrefreshingtastewithatangyaftertastethatmightbebenefici alto yourhealth (Jayabalanetal., 2014).

Sauerkraut - One of the oldest and most popular traditional fermented vegetables is sauerkraut, which has long been used for its therapeutic properties in China. Let's focus on sauerkraut, eaten in European countries, and the dish primarily seen inGermancuisineforcenturies. When sauerkraut spontaneously ferments, several microbiological, chemical, and physical changes occur that may compromise the product's safety and quality.Whencabbagefermentsnaturallythroughlacticacidbacteria,itbecomesthiszesty delicacy thatcarries healthy probiotics.

Kefir - Middle East/Caucasus: Kefir is a dairy-based drink that goes through fermentation giving itprobiotic properties mostly found in the regions comprising of the Middle East and Caucasus. It's asilky-smooth drink with an acidic tinge having its origins in areas encircling the Black Sea producedessentiallyby fermentingmilk usingkefirgrains (Farnworth,2005). Kefir has attracted interest recently due to its pleasing organoleptic qualities as well as its anti-hypertensive, anticarcinogenic, hypocholesterolemic, anti-inflammatory, anti-mutagenic, anti-allergenic, anti-bacterial, anti-diabetic, antioxidant, and probiotic effects.

Tempeh - a popular Indonesian food, is derived from fermented soybeans and presents a protein-rich profile. The distinct texture and satisfying umami flavour of this food product are contributed by Rhizopus oligosporus - an essential mould used in the fermentation procedure (Hesseltine, 1965).

Miso - miso paste is at the heart of Japanese cuisine as it serves as a crucial ingredient for flavorfuldishes across the land of the rising sun. Combining soybeans, salt with koji -a mould-based agent-deliversanauthentictastetosoups, sauces, andmarinades alike(Franzetal., 2014). It is also a rich source of probiotic bacteria; it is good for immune system and works as an antiinfection agent in the body. It is prepared by mixing koji and cooked soybeans.

Cheese-
Todigressfromdiscussingfermentedfoodsgloballywouldbeincompletewithoutmentioningcheese. The global diversity of cheese-making practices results in a dazzling array of

sensationaltexturesandflavours.Thisintricatecraftperfectlyillustratestheboundlesspossibilitiesthatfermentation can bring to life - think creamy Brie from France or smoky blue cheese from the UnitedStates. In the process of making cheese, casein is broken down by the use of milk, rennet, starter culture, proteases, and peptidases from secondary microbial flora. These bioactive compounds are then employed in a variety of biological processes.

The effects of cheese in preventing and treating illnesses are mostly due to its vitamin and mineral content as well as bioactive peptides (antihypertensive, antioxidant, opioid, anti-proliferative and antimicrobial peptides and conjugated linoleic acids (CLA)) (Hur et al., 2017). Furthermore, there is an extensive list of other intriguing food items awaiting exploration in futuretopics.

The processof fermentation

We now shift our attention to the series of events that unfold during fermentation.Stage1-Introduction ofMicrobes:

Fermentation commences with the introduction of specific bacteria into a substrate, usually sugars,whichserveastheprimaryfuelsourceforthesemicroorganisms.Thiscrucialphaseisoftenreferredtoas "inoculation". The choice of microbes varies depending on the desired end product,ranging from *Saccharomyces cerevisiae* in bread to *Lactobacillus* in yogurt (Ganzle., 2015).

SugarBreakdowninStage 2:

Once the microbes are introduced, they begin breaking down complex carbohydrates into simplersubstances such as ethanol, lactic acid, or carbon dioxide. This metabolictransformation plays a vital role in the development of flavor, texture and overall preservation of thefinalproduct(Fleet., 2007).

FlavorEnhancementinStage 3:

Theabilitytoenhancefoodflavorprofileisoneoffermentation'smostrenownedattributes.Theunique taste and enticing aroma that characterizes resulting products are brought about by a wide array ofvolatilecompoundsproducedbymicrobesduringthisintricateprocessincludingesters,aldehydesandacids (Spitaelsetal., 2014).

Step4-pH upkeep:

Maintaining the right acidity of the environment during fermentation plays a pivotal role in the wholeprocess.Tocreatesurroundingsthatfostertheirgrowthandmetabolicfunctions,microorganismsoftenmodify the pH levels by producing acids or alkaline substances (Fleet., 2007). For example,when preparing sourdough bread, lactic acid bacteria reduce the pH, this gives it a distinctive tangytaste(Gobbettietal., 2014).

ControlandMonitoring inStep5:

Precisely regulating and closely watching variables like temperature, humidity, oxygen levels etc areparamount for successful fermentation. These factors directly influencemicroorganisms' development, activity and even slight fluctuations can significantly alter the finalproduct'squality.

Time frame: Fermentation processes vary from weeks to months for products like matured cheeses or can be relatively quick such as hours required to raise bread dough. The duration depends on factors like type of involved microorganisms and desired characteristics of the end product. According to the Tamang et al study, fermentation can also act as a natural preservative while adding flavour. The acidity and production of antibacterial elements during fermentation allows many fermented foods to have longer shelf lives (Doyle, 2007).

Various aspects of fermented foods.

Fermented foods are rich in vitamins, minerals, proteins and fibre. These foods act as potential probiotics and antioxidants due to which we get numerous health benefits. Value addition is another significant role of fermented food products which leads to enhancement of flavour, improvement of texture, shelf life is extended and gives a diverse flavour with unique aroma.

Different types of microorganisms are used in the metabolic process of fermentation, including bacteria (e.g., Lactobacillus and Bifidobacterium), yeasts such as saccharomyces and some moulds. Preservation of foods can be easily done by fermentation naturally.

In food industries fermented foods are produced on a large scale with proper quality control, consistency and safety.

Table 1representingvariousaspectsoffermentedfoods.

Fermented foods	**Health benefits**	**Value addition**	**Microorganisms involved**	**Raw materials used**	**References**
Yoghurt	Probiotics for gut health, calcium source, protein	Flavour enhancement, texture improvement	Lactic acid bacteria (*Lactobacillus bulgaricus,Streptococcus thermophilus*)	Milk	Parvez et al., 2006. Tamang et al., 2010
Kimchi	Rich in vitamins (C, K), probiotics, antioxidants	Enhanced flavour, preservation	Lactic acid bacteria (*Lactobacillus plantarum*), wild yeast	Napa cabbage, radishes, spices	Cheigh and Park.,1994.
Kombucha	Probiotics, antioxidants, potential detox effects	Fizzy drink, pleasant taste	Symbiotic culture of bacteria and yeast (SCOBY)	Tea, sugar, SCOBY	Dufresne et al.,2000. Vina et al.,2014.
Sauerkraut	High in Fiber, probiotics, vitamin C	Improved flavour, preservation	Lactic acid bacteria (*Lactobacillus* species)	Cabbage, salt	Marco et al.,2017. Sanchez et al.,2016.

Miso	Good source of protein, vitamins, and minerals	Umami flavour, extended shelf life	*Aspergillus oryzae* (for koji), Lactic acid bacteria (varies)	Soybeans, salt, rice/barley koji	Hutkins., 2006. Ray and Ward., 2008.
Tempeh	Rich in protein, probiotics, vitamins (B2, B3)	Nutty flavour, firm texture	*Rhizopus oligosporus*(starter culture)	Soybeans	Steinkraus.,1995. Hesseltine.,1979.
Kvass	Probiotics, low-alcohol content, vitamin C	Refreshing taste, extended shelf life	Lactic acid bacteria (*Lactobacillus* species)	Bread, water, sugar, flavourings	Wang et al., 2022. Sanko et al.,2017.
Sourdough Bread	Easier digestion, lower glycaemic index	Unique flavour, longer shelf life	Wild yeast (*Saccharomyces cerevisiae*), lactic acid bacteria (Lactobacillus species)	Flour, water	De Vuyst and Neysens.,2005. Steinkraus.,1996
Pickles (Lactose-fermented	Probiotics, vitamin K	Tangy flavour, extended shelf life	Lactic acid bacteria (*Lactobacillus* species)	Cucumbers, salt, spices	Fu.,2020.
Natto	High in	Unique	*Bacillus*	Soybeans	Liu et al.,

	protein, vitamin K2	flavour, sticky texture	*subtilis* (starter culture)		1998. Fox et al.,2004.
Cheese	Good source of calcium, protein	Diverse flavours, extended shelf life	Various lactic acid bacteria, moulds, yeasts	Milk, rennet, specific cultures	McSweeney et al.,2013. Tamang et al.,2010.
Fermented fish paste	Rich in protein, essential fatty acids	Unique taste, preservation	Salt-tolerant lactic acid bacteria, moulds	Fish, salt	Steinkraus.,1996. Nishida et al.,2008.
Cocoa	Improved flavour, potentially probiotic	Enhanced aroma, preservation	Wild yeasts, lactic acid bacteria	Cocoa beans	Papalexandratou and Vuyst.,2011
Fermented soy sauce	Rich in umami flavour, antioxidants	Enhanced flavour, preservation	*Aspergillus oryzae* (for koji), lactic acid bacteria	Soybeans, wheat, salt	Luh.,1995

Yoghurt: Yoghurtisasalutaryadditivetoone'seatingpatternsinceitcomeswithprobioticcharacteristicsthatendorseintestinalwellness.Furthermore,itrepresentsanexcellentsupplyofproteinand calcium. The noteworthiness of yoghurt is such that it enhances health as well as the tang andtexture of nourishment. Moreover, its maturation procedure that commences with milk functioning astheinitialmaterialreliesheavilyonlacticacidbacteria,particularly*Lactobacillusbulgaricus*alongside*Streptococcusthermophilus* (Parvezetal., 2006).

Kimchi: Kimchi represents a customary Korean dish possessing probiotics, antioxidants together withnutrients like vitamins C & K among others. Besides enriching flavour of victuals, it also functions asapreservationmechanism.ConstituentslikeNapacabbagecoupledupwithradishescombinedtogetherwith spices undergo fermentation under the influence of lactic acid bacteria specifically *Lactobacillusplantarum*allied to wild yeast(Cheighand Park., 1994).

Kombucha: The renowned fermented tonic kombucha gained notoriety for its probiotics, clutchingantioxidants as well as probable purifying properties. It won acclamation for its fizzling palatableflavour.GenerallyrawinputconstituentsconsistteaalongwithsugaralongwithSCOBY in fermentation process which makes use of symbiotic culture comprising bacteria plus yeast (SCOBY)(Dufresneand Farnworth., 2000).

Sauerkraut: SauerkrautowesitsimmensepopularitytotheabundanceoffIber,probiotics,andVitaminCthatitpossesses.Thefermentingprocesshelpsenhancetasteandextendsshelflife.Thefermentationofcabbageutilizingsaltasitsprimaryconstituentisfacilitatedbyvariousstrainsoflacticacidbacteria, prominently*Lactobacillus* species (Macfarlaneetal., 2011).

Miso: miso, a versatile fermented food, also boasts of being a rich source of vitamins, minerals andprotein.Itprolongsthelifespanofproductswhileaddinganumamitastetodishes.Soybeanscombinedwith salt and rice or barley koji form the raw materials during the fermentation along with *Aspergillusoryzae*forkojiand differentstrains of lacticacid bacteria(Hutkins., 2006).

Tempeh: Tempeh derived from soybeans offers not only an excellent supply of protein but alsoprobioticsandvitaminsB2andB3.Itssolidstructurepairedwithanuttyflavormakesitafavoredmeatsubstituteoption.Toinitiatethefermentationprocess*Rhizopusoligosporus*isusedasastartingculture(Steinkraus., 1995).

Kvass: Kvass is an exciting beverage option as it combines probiotic-rich attributes with low alcohollevelswhile ensuringhighvitaminCcontenttoo.Intermsofstoragecapability,itoutranksothersinitsclass while holding on to its distinctively pleasant flavor profile. Bread mixed with water sugar andflavoringsarekeycontributorsduringfermentationtogetherwithlacticacidbacteriaprimarily*Lactobacillus*species.

Sourdough Bread: When compared to regular bread, sourdough bread's glycemic index is lower andeasiertodigest.Itstaysfreshforalongerperiodoftimeandhasauniquetaste.Theprimaryingredientsusedarewheatandwater,requiringfermentationbynaturallyoccurringwildyeastsuchas*Saccharomycescerevisiae*plus lacticacid bacteria(DeVuystand Neysens., 2005).

Pickles: Lacto-fermented pickles provide vitamin K and probiotics. They have a tart flavor and last along time on the shelf. Thefermentation process involves cucumbers being fermented with salt as well as spices using lactic acidbacteriaprimarily fromthe*Lactobacillus* strain.

Natto: Famousforitsthickconsistencyanddistincttaste,nattoispackedwithproteinplusvitaminK2.Soybeans are utilized as raw material for fermenting it while *Bacillus subtilis* serves as the startingculture(Liuetal., 1998).

Cheese: Cheese is a dairy product that contains substantial quantities of calcium and protein. It has anextended shelf life plus various flavor. Basic ingredients utilized in its fermentation process includemilk, specific cultures, and rennet while multiple types of lactic acid bacteria strains, yeasts, moldsfacilitatethis process(McSweeneyetal., 2013).

Fermented Fish Paste: Fish that has undergone fermentation produces an appetizing paste that isbrimming with valuable protein and crucial fatty acids. Notably, it imparts a remarkable taste whileserving as an effective method of preservation. During fermentation, fish and salt are employed asstarting ingredients. This transformative process is facilitated by bacteria that can tolerate high levelsof saltand moulds (Nishida et al., 2008).

CocoaBeans: Renownedfortheirtasteenhancementandperhapsprobioticattributes,fermentedcacaobeans help maintain freshness and enhance aroma. During fermentation, wild yeasts and lactic acidbacteria areutilized.Therawmaterialof choiceiscocoabeans(Papalexandratouand Vuyst.,2011).

FermentedSoysauce: Withhighumamitasteandabundantantioxidants,fermentedsoysauceliftsthe palateexperience andensureslonglastingquality.Rawingredientsemployedinfermentationincludes soybeans,wheat,saltalongwith*Aspergillusoryzae*bacterium,akeyingredientforkoji (Luh.,1995).

Health benefits of fermented foods.

Control and prevention from chronic disease

Fermented foods and beverages are increasingly understood to have a variety of bioactive compounds and related mechanisms of action, despite the challenges in identifying which of the many functional components that make up a single fermented food or beverage may confer the potential health benefit. Studies on humans and animals that evaluate a variety of health-related outcomes at particular intake levels of fermented foods will be helpful in examining the co-regulation of lipid profiles, oxidative stress, cellular energy and metabolism, immune system function, and cognitive support. Information from both human and animal research has been included for a number of the fermented foods that are the subject of this discussion. Additionally, clinical trial methods, dosage schedules, and the incorporation of a variety of secondary endpoints are covered. Furthermore, we must stress that extrapolating an appropriate amount of fermented food and dietary intake level to humans from the current animal research is fraught with substantial complications. The potential health benefits of fermented foods for individuals with chronic illnesses might also be attributed to dietary patterns, the host nutrigenome, and the gut microbiota (Daniell and Ryan, 2012).

Cures blood pressure and hypertension

Blood pressure appears to be lowered temporarily but significantly when blueberries are fermented by Lactobacillus plantarum tannase-active probiotic strains (Ahren et al., 2014). Hypertension is a severe condition that is a significant risk factor for cardiovascular disease. It is characterized by a systolic blood pressure of more than 140 mmHg or a diastolic blood pressure of more than 90 mmHg. Systolic and diastolic blood pressure were both dramatically lowered after two weeks of consuming 2 grams of lacto-fermented blueberries per day, but they returned to hypertensive levels two weeks after the intervention finished, according to research using a rat model of hypertension. (Ahren et al., 2014).

Maintains glucose and insulin levels

Up to 50 ginsenosides have been found to date, and they may help regulate insulin and blood sugar levels. Red ginseng roots are another plant that contains bioactive components, such as saponins (ginsenosides) and nonsaponins (Oh et al., 2014). It has been shown that ginseng roots may be fermented to boost the amount of saponins the plant naturally produces. For four weeks, those who took 2.7 g of fermented red ginseng daily saw lower levels of postprandial glucose and fasting insulin, and higher levels of both (Oh et al., 2014).

Controls diabetes

Discussion is warranted since a fermented papaya preparation (FPP) has proven bioactivity in adult diabetics with specific potential for immune modulation and antioxidants. By directly modulating the response of wound-site macrophages and the subsequent angiogenic response, Dickerson and colleagues provided the first experimental data suggesting that FPP may enhance diabetic wound outcomes (Dickerson et al., 2015). Because FPP has been shown to be safe and has no negative effects on patients' hyperglycemia, the idea that it might treat abnormalities in the respiratory burst capability of peripheral blood mononuclear cells in type 2 diabetes mellitus patients has significant significance.

Acts as anticancer products

The goal of the therapeutic method is to activate natural killer (NK) cells, which mediate anticancer action through a nonspecific immune response, by fermenting isolated polysaccharides from rice bran by fungus. To be more precise, rice bran was broken down by the carbohydrolase that the Lentinus *edodes mycelia* produced. This produced a fraction of active polysaccharides that promote the proliferation of immune cell macrophages, with a focus on NK cell activation and anticancer activity (Choi et al., 2014).

Different implementations of fermentation

Yeast Fermentation for Bread Making:

Saccharomyces cerevisiae, sometimes known as baker's yeast, is the yeast that is used to make bread. The primary products it produces from the fermentable sugars in the dough are ethanol and carbon dioxide. The kind of yeast and the presence of fermentable sugars in the flour, such as maltose from starch hydrolysis, determine how intense the fermentation will be (Hutkins, 2006). Baker's yeast cells want to become osmotolerant in order to avoid fatal damage, but the development of osmotolerant strains of baker's yeast will require an understanding of the molecular mechanisms involved in high-sucrose stress lenience, such as the introduction of stress proteins, the accumulation of stress protectants, and the changes in membrane composition (Shima & Takagi, 2009).

Alcoholic Fermentation for Beer Production:

Many of the modern brewers rely on dried yeasts, liquid or frozen preparations from yeast centers and strain collections, as opposed to traditional breweries that have been cultivating their own brewhouse yeast strains for decades or even centuries. In order to appeal to a growing market that values distinctive flavors, some conventional and experimental brewers utilize spontaneous fermentation and have developed their own culture collections over time. The potential of these strain collections is enormous, and an increasing number of brewers are daring to experiment with new and ancient yeasts to produce novel goods such maltose-negative yeast strains-produced non-alcoholic beers (Methner et al., 2019).

Acetic Acid Fermentation for Vinegar Production:

Two primary processes are used in the industrial production of vinegar: a quick submerged fermentation process and a slow procedure employing static surface acetic acid fermentation. Traditional vinegar manufacture often uses static fermentation. Although the fermentation process takes a while to finish, this method produces good-quality products at a low cost in terms of plant investment. Static fermentation of an alcoholic vinegary liquid (moromi) is done in suitable covered containers, which is thought to be a good method of avoiding bacterial infection. The moromi's surface is covered with a crepe pellicle of acetic acid bacteria within a few days, at which point the fermentation starts and lasts for almost a month. There are no rigorous sterilizing procedures in this process.

Fermentation for Biofuel Production:

The low cost of biofuels has not materialized as promised. Although they have a lower energy density, alcohols are now a more promising biofuel than biodiesel or hydrocarbons because their synthesis routes don't rely as much on the supply of ATP and because they can ferment anaerobically. Large quantities of ATP are needed for the production of hydrocarbons and biodiesel, which is often limited to aerobic environments and whose productivities are extremely sensitive to the P/O ratio (He et al., 2014; Varman et al., 2014).

Fermentation in Pharmaceutical Industry (e.g., Antibiotics):

The strong correlation that exists between particular illnesses and microbial activity justifies the function of microorganisms. Numerous discoveries and innovations, as well as significant developments in the pharmaceutical and medical sectors, have been made possible by microbiology. Though many microorganisms are important for the immune system and digestive system, they also cause a variety of microbial infections and infectious illnesses, including HIV. Pharmacists and microbiologists are collaborating to develop medication treatments that specifically target bacteria that cause opportunistic infections instead of the human body's host cells. Antibiotics are antimicrobial agents with the power to either stop or eradicate bacteria, fungus, and other microorganisms. These are the components that the bacterium produces and which work against the growth of other microorganisms. Due to advances in medical research, the majority of antibiotics used today are natural substances derived from microbes, such as penicillin and some fungi called Penicillium (Gaynes, 2017).

Conclusion

This review depicts that fermentation in food processing plays an important role in enhancing theflavour of our food products and leads to value addition. We can conclude here that fermentation hasbidirectional aspects with respect to food quality and plays an important role in economy all over theworld. We can say that fermentation is one of the most important chemical processes involved in foodprocessing which leads to many health benefits and value addition of food products. Fermented foodproducts and beverages are historically an important part of human diet and provides many healthbenefits.

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