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MICROBIAL FERMENTATION AND ITS ROLE IN QUALITY IMPROVEMENT OF FERMENTED FOODS

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Abstract: The nutritional and biological content of the basic components is frequently altered throughout the fermentation process in foods. Fermented foods include intricate ecosystems of enzymes derived from raw ingredients that interact with the metabolic activities of fermenting microorganisms. Fermenting microorganisms use physical and metabolic changes in fermented foods to provide a novel approach to food stability. Antioxidants, peptide synthesis, organoleptic and probiotic qualities, and antibacterial activity may all be advantages of fermented foods over plain foods. It also affects the levels of antinutrients and toxins in the body. The quantity and quality of microbial communities in fermented foods varies depending on the manufacturing process and storage conditions. This review adds to current knowledge on biochemical changes that occur during food fermentation. Modifications of biochemical components that determine the eristic character of final fermented food products from source food resources will be given special focus.

Keywords: enzymes; fermenting microorganisms; biochemical changes; fermented foods

I. INTRODUCTION:

Fermentation is a microorganism-assisted process that breaks down large organic molecules into simpler ones. For example, yeast enzymes break down sugar and starch into alcohol, while proteins are broken down into peptides and amino acids. Food has a tendency to ferment, resulting in beneficial biochemical changes that are responsible for a major shift in the food required for cooking, as well as a safer product (Nkhata *et.al*, 2018, Xiang *et.al*, 2019). As a result, microbes play an important role in the fermentation of ingredients by revealing changes in the chemical and physical properties of the ingredients. (Melini *et al*., 2019, Sanlier *et al.*, 2019) Fermented foods have a number of benefits:

1. Fermented ingredients last longer on the shelf than unique ingredients.
2. The improvement of organoleptic properties; for example, cheese has more flavor-enhancing organoleptic properties than its raw substrate, milk.
3. The removal of harmful/undesirable compounds from uncooked materials—for example, the toxic cyanide content material of cassava may be reduced during garri preparation, and the flatulence ingredients in soybeans are eliminated by fermentation.
4. Dietary residences are improved due to the presence of fermenting microorganisms. Yeast in bread and yeast and lactic acid microorganisms in garri, for example, contribute to its nutritional value.
5. Fermentation reduces the cooking time of foods such as Ogi (fermented corn) and soy products, which are popular in West Africa.
6. Fermented goods have a higher antioxidant capacity in vitro; for example, biopeptides are generated following proteolysis of milk proteins, particularly -casein, -lacto albumin, and -lacto globulin, therefore fermented milk and yoghurt have stronger antioxidant characteristics than milk.

The key elements influencing fermented foods are the makeup of the substrates utilised and the fermenting microorganisms. Furthermore, the handling of food and the length of fermentation during processing have an impact on food fermentation (Ok a for.2009). Lactic acid bacteria (L.) are the most common microbiota found in fermented foods and beverages, and they are thought to be the most important factor in the good benefits of fermented foods and beverages (Mokoena and M.P. 2017). L. such as Enterococcus, Streptococcus, Leuconostoc, Lactobacillus, and Pediococcus, as well as yeasts and moulds such as Debaryomyces, Kluyveromyces, Saccharomyces, Geotrichium, Mucor, Penicillium, and Rhizopus (Mokoena and M.P. 2017). (Anukam*et.al*, 2009, Blandino *et.al*, 2003, Vagelas *et.al*, 2011, Doyle *et.al*, 2006).Despite their beneficial effects during fermentation, microbes in food also aid in the prevention of numerous dangerous bacteria and toxins. These microbes are also responsible for the production of new digestive enzymes.

II. Improving the nutritional quality of foods fermented by microorganisms:

Fermented foods are thought to be more nutrient-dense than unfermented foods (Hasan *et.al*, 2014). Fermented foods have a better nutritional value because of the fermenting microorganisms they contain, and there are three types of microbial fermentation:

Catabolic and danabolic microorganisms break down complex chemicals and synthesize complex vitamins and other growth factors (Kennedy 2016).

Indigestible compounds release nutrients that have been blocked in plant structures and cells, which is a regular occurrence in individual seeds and grains. The cellulosic and hemicellulosic components that surround the endosperm (i.e., rich in proteins and digestible crabs) have been physically broken down to release nutrients during the milling process. In less developed areas, raw milling is employed to extract nutritional content; however it is insufficient to unleash the entire nutritional worth of plant items. Some of the bonded nutrients remain unavailable to the human digestive system even after heating. At the same time, certain bacteria, moulds, and yeasts can help alleviate this problem by physically and chemically breaking down the cell walls and indigestible shells of these items (Hasan *et.al*, 2014)

Enzymatic breakdown of polymers, which are not, digested by humans, into simple sugars and their derivatives such as cellulose, hemicellulose, and a similar form of polymer, is another way for enhancing the nutritional qualities of plant material. Cellulosic substrates in fermented foods can be enhanced for human consumption using microbial enzymes (Potter *et.al*, 2006). Many grain-based diets are nutritionally deficient and are taken as staple foods by the impoverished. However, yeast and L. fermentation have been shown to improve the nutritional content and digestibility of food. It also boosts microbial enzyme activity by providing an acidic environment at a temperature of 22-25 °C. (Mokoena *et.al*, 2005).The reduction of antinutrients, such as tannins and phytic acid (degradation with the help of phytases), which leads to a higher bioavailability of simple sugars or polysaccharides (amylases), proteins (proteases), free fatty acids (lipases), and iron, is a critical role of enzymatic hydrolysis in fermented foods.

III. Effects of lactic acid fermentation on food nutrition:

The digestibility of food and the amount of essential nutrients are two major aspects that influence its nutritional value. Fermentation can improve nutrient absorption as well as digestibility. Enzymes in fermented microorganisms can digest macronutrients first during the fermentation process. Fermentation can improve the nutritional quality of food in a variety of ways, including raising the quantity and bioavailability of nutrients as well as increasing the density of nutrients. This can be accomplished by synthesizing absorption promoters, degrading anti-nutritional factors, modulating nutrient uptake, and performing protein predialysis (Nkhata *et.al*, 2018). Lactic acid fermentation improves the availability of some limiting minerals and amino acids (Rollan *et.al*, 2019). Tannins, phytates, and oligosaccharides are all reduced by 50%, and oligosaccharides are reduced by 90%. (Samtiya *et.al*, 2020).Nutritional effects of fermented foods, both direct and indirect, on nutritional disorders Food fermentation have a direct therapeutic effect on the body (Hill *et.al*, 2017). Food fermentation also benefits consumer health by increasing the number of vitamins accessible, such as niacin, thiamine, folic acid, and riboflavin (Melini *et.al*, 2019). It also enhances iron absorption by breaking down complex molecules into inorganic iron when combined with vitamin C. (Nkhata *et.al*, 2018).

By lowering indigestible substances un plants such as glucuronic and polygalacturonic acids, cellulose and hemicelluloses, fermentation boosts the bioavailability of rare minerals and trace elements (Gupta *et.al*, 2015) It also reduces serum cholesterol levels by preventing cholesterol production in the liver and dietary and endogenous cholesterol absorption in the gut (Jesch *et.al*, 2017). Avoid diseases/infections such as diarrhea and salmonellosis by keeping the product stable and safe (Minh, N.G.2014).

IV. Enrichment and modification of biological components in fermented foods:

A) Peptides Production:

Proteolytic microbes (mostly Bacillus) create bioactive peptides (B.A.P.s) during food fermentation (De Mejia *et.al*, 2010, Nagai, T.; Tamang. 2010). Peptides exhibit antihypertensive characteristics (Phelan, M.; Kerins. 2011) and also serve as antithrombic drugs and immunomodulators (Hou, J.C. *et al.*, 2015). (Alcantara, C. *et.al*, 2016) B.A.P.s production is still below the standard due to a lack of large-scale manufacturing facilities and the high cost of enzymes for protein hydrolysis. Microbial fermentation, on the other hand, is a less expensive and less expensive technique of manufacturing BA.Ps. B.A.Ps contains the health benefits associated with dairy products. PrtB from *L. delbrueckii* subsp. *bulgaricus* (Vukotic, G *et al*, 2016), PrtP from L.casei and L.paracasei are all examples of cell envelope proteinase (C.E.P.s) (Griffiths *et.al*, 2013), PrtR from *L.rhamnosus* and *L.plantarum* (Miyamoto *et al.*, 2015), and PrtH from *L.helveticus* (Miyamoto *et al.*, 2015). (Stefanovic, E, E, E, *et.al*, 2017). In most *Lactobacillus* species, there is only one C., but the presence of four PrtH paralogs (i.e. *L.helveticus* is the most proteolytic species of the genus *Lactobacillus*, entirely responsible for the formation of distinct B.A.P.s, due to varied C.paralogs and specificities (Qian, B.; Xing *et.al*, 2011).

Some previously fermented milk products, such as koumiss kefir, yoghurt, cheese, fermented camel milk, and fermented fish products, showed activity associated to angiotensin inhibition of the converting enzyme (A.C.E). Fermenting soy products produces bioactive peptides, which aid in the prevention and treatment of a variety of metabolic illnesses (Sanjukta *et.al*, 2016).

B) Anti-Nutritive Compounds Degradation:

Nutritional inhibitors are found in almost all dietary substrates. They are hazardous to humans and are responsible for decreasing the nutritional content of foods, hence limiting the availability of nutrients to the body. Rubbing, dehydrating, washing, peeling, fermenting, and roasting are some of the methods used to reduce the amount of cyanide in various African fermented cassava, gari, and fufu products (Omolara. 2014). The cyanogenic glucoside lotaustralin and linamarine are detoxified by *Lactobacillus*, *Streptococcus*, and *Leuconostoc* in the traditional techniques of manufacturing fufu and gari to create low boiling point hydrocyanic acid (H.) which escapes during the roasting process of the dried cassava tubers. Fruit pulp renders the final product non-toxic and safe to eat (Bamidele *et.al*, 2015).However, *R.oligosporus*, which is used in Tempe, transforms indigestible oligosaccharides like Verbascosa and stachyose into absorbable monosaccharides and disaccharides, removing flatulence (Sanchez.2008). Phytic acid is reduced during Idli and Rabadi fermentation as anti-nutritional chemicals in the *B. subtilis* film are broken down (Tamang, J.P *et.al*, 2016)

C) Biochemical Changes during Cereal Fermentation:

Grains are the world's most important source of crabs, dietary proteins, minerals, fiber, and vitamins (Laskowski, W *et.al*, 2019). Consumer acceptability of the nutritional quality and sensory qualities of cereals, on the other hand, is a major issue. Dairy products have a lower protein concentration than milk and dairy products because to a lack of several necessary amino acids, such as those found in cereals (Verni, M *et.al*, 2019).

Various methods, such as genetic engineering and amino acid supplementation with protein concentrates or alternative protein-rich sources such as defatted oilseed / grain legume meal, have been used to reduce the nutritional value of cereals. However, various processing technologies, such as sprouting, cooking, fermenting, and milling, improve the nutritional quality of cereals, with fermentation being the best (Verni, M *et.al*, 2019). Natural fermentation of cereals reduces carbohydrate content by adding indigestible oligo- and polysaccharides, which enhances vitamin B group availability and amino acid synthesis (Erkmen, O *et.al*, 2016).Natural fermentation increases the enzymatic breakdown of phytates by providing appropriate pH conditions for polyvalent cations including zinc, iron, magnesium, and calcium to exist in complex form. Via big wrinkles, and zinc (Nkhata *et.al*, 2018).

The effect on amino acid and protein content after fermentation is debatable; for example, in maize flour, the concentration of accessible methionine, tryptophan, and lysine is enhanced (Nkhata *et.al*, 2018). The protein quality of cereals such as millet, maize, sorghum, and other grains is greatly improved by fermentation, in addition to the lysine content (Singh, A.K *et al*, 2015). (Mariod *et.al*, 2016). During the Uji manufacture, the tryptophan concentration doubled, whereas the lysine content decreased significantly (Blandino *et.al*, 2003). It demonstrates that fermentation has an effect on the nutritional value of foods, and that the evidence for improvement is strong. Fermentation in food increases the product's taste, texture, flavors, aroma, and, most importantly, shelf life.

Various volatile chemicals are produced during the fermentation of cereals, resulting in a diverse flavour combination in the finished product (Erkmen, O *et.al*, 2016). Aroma-forming chemicals like butyric acid and diacetyl acetic acid, in addition to scents, make fermented cereal products more appealing (Blandino*et.al*, 2003).

Grains (such as wheat, rice, wheat, sorghum, or corn) are the key element in traditional fermented foods and beverages prepared in most parts of the world. Some of these grains are significant foods in human nutrition, while others can be used as spices, colors, breakfasts, and beverages. Fermentation takes happen with natural or mixed cultures such as bacteria, fungus, and yeast in maximally fermented grain products. These microorganisms function in tandem or one after the other during fermentation, changing the dominant microbiota (Nkhata *et.al*, 2018).

The most frequent fermenting bacteria include *Bacillus, Lactobacillus, Micrococcus, Streptococcus, Pediococcus,* and *Leuconostoc* species. In addition, the genus contains *Cladosporium, Aspergillus, Trichothecium, Paecilomyces, Fusarium, and Penicillium*, the most prevalent fermenter of fermented mushrooms. PH, water activity, salt content, temperature, and the makeup of the food matrix are all elements that influence the development of fermented microorganisms in fermented foods and beverages. L.A.Bs (Rezac, S. *et al*, 2018) broad acceptance mediates the fermentation of food by the most prevalent bacteria. When grain is washed and immersed in water for a few days during natural fermentation, a sequence of natural microbiota is formed, which is dominated by a large number of L. Amylases make sugar during this sort of fermentation. It is used as a source of energy by lactic acid bacteria Other processes, such as shrinking, salting, or heating, contribute to the final products in addition to fermentation (Liptakova, D *et.al*, 2017)

L. was characterised by Aguirre and Collins. Bacilli and cocci that is gram-positive, immobile, non-porous, and catalase-negative. Lactic acid is produced by fermenting carbohydrates. The routes are split into two groups based on the utilisation of hexose sugars: homofermentative and heterofermentative (Aguirre, M *et.al*, 1993).

In homofermentative pathways, the only end or primary product of glucose fermentation by some lactic acid bacteria such as *Streptococcus, Pediococcus, Lactococcus*, and some *Lactobacilli* is lactic acid; in heterofermentative pathways, the end products ethanol, lactate, and CO2 are produced by microorganisms such as *Leuconostoc, Weisella*, and some *Lactobacilli* (Liptakova, D *et.al*, 2017). Lactic acid fermentation technology has also been proven to be effective as a preservative in certain cereals. Hydrogen peroxide, antibiotics, and organic acids were produced during the mediated antibiosis.

The formation of organic acids by L. lowers the pH value below 4.0, putting perishable microorganisms found in grain under stress. The acid's action on the bacterial cytoplasmic membrane has an antibacterial effect because it makes maintaining the membrane harder. Possible influence on active traffic In addition to producing organic acids, L. creates hydrogen peroxide by oxidizing reduced nicotinamide adenine dinucleotide with flavin nucleotides, which react fast with oxygen (NADH). It can also store the catalase enzyme (since catalase is not present in L.). Hydrogen peroxide is broken down and many bacteria are inhibited. Lactic acid fermentation can help enhance iron absorption in high-tannin grains by lowering tannin levels (Gupta *et.al*, 2015).Fermentation by L.it also contributes to viricidal and anti-tumor activities (Garneau, J.E.; Moineau, 2011). (Aragon, F *et.al*, 2014).

Because legumes can supply a considerable amount of lysine but are lacking in sulfur-containing amino acids, most legumes produced or consumed in Asia and Africa have been supplemented with grains to increase the overall quality of the proteins in the fermented product. They contain a lot of methionine and cysteine but not enough lysine (Hagan, N.D *et.al*, 2003).

D) Vitamins Bio-Enrichment:-

As a public health strategy, certain manufactured foods are fortified with nutrients, primarily vitamins. For instance, vitamin D is added to milk and riboflavin during bread preparation, while ascorbic acid (vitamin C) can be fortified in fruit. The biological enrichment of foods should be accomplished by most nations using this form of food fermentation (Charade *et.al*, 2019). Because of the use of highly polished white rice, there is a thiamine (Vitamin B1) deficit. Beriberi, a condition that can result in strokes and paralysis, can be brought on by this kind of rice (Wiley *et.al*, 2019).The microbes responsible for the tape Keta fermentation produce thiamine. The repair of the thiamine level in unpolished rice is another function of these microbes (Law, *S.V.et al*, 2011).

The fermentation process results in the partial hydrolysis of proteins, the hydrolysis of lipids to their constituent stachyose (a tetrasaccharide that humans cannot digest), fatty acids, a doubling of riboflavin, a sevenfold increase in niacin, and the synthesis of vitamin B-12, which is typically lacking in vegetarian foods, by a fermenting bacterium that is co-growing with the necessary mould (Noutet.al. *2005).* Many bowls of cereal/legume mixes cook more quickly and have better texture and digestion because to the use of temperature in the manufacturing process. When added to the fermentation of Indian Idli, the bacterium *Klebsiella* *pneumoniae* (nonpathogenic strain) produces vitamin B-12 (Ghosh, *et.al* 2011). Due to its abundance in nutrients including niacin, thiamine, pantothenic acid, riboflavin, p-amino benzoic acid, and biotin, and pyridoxine, pulque is widely consumed by Mexican youngsters from low-income households (Giles-Gomez *et.al,* 2012). Beverages, such as Kaffir beer, have a nice sour flavour and thin gruel texture. The thiamin level in people ingesting maize remains constant during fermentation as a result of this alcoholic beverages increased riboflavin and nearly doubled niacin/nicotinic acid levels. People that eat rice may find this to be quite helpful (Aka *et.al,* 2014).

Palm sap is a colourless, clear liquid that contains 10–12% fermentable sugar and is a sweet, plump, milky white suspension of bacteria and yeasts (Amoa-Awua *et.al,* 2007). It is eaten in tropical regions. Ascorbic acid content in this sort of wine is roughly 83 mg/L (Karamoko *et.al* 2016). Palm that has gone bad Thiamine concentrations in wine are raised to 25–150 g/L, pyridoxine to 4–18 g/L, and riboflavin to 35–50 g/L. Unexpectedly, palm wine has a significant level of vitamin B-12 (190 to 280 g/mL).The cheapest source of vitamin B is palm toddies, which are also an important source of money for nutrition. In the tropics drained (Anal *et.al,* 2016).

(E) Presence of Biogenic Amines in Juices and Vegetables Fermented with Lactic Acid Bacteria:-

Biogenic amines (B.A.) are amines with low molecular weight and strong biological activity that are typically found in foods and beverages (Ravishankar *et.al* 2016). Multiple vasoactive symptoms and/or psychoactive effects are brought on by excessive B.A. consumption (Ruiz-Capilla ,*et.al* 2019).

Food decomposition during controlled or spontaneous fermentation typically results in a rise in B.A. concentration, where elements like temperature, pH, oxygen content, or sodium chloride content adversely affect the development of B.A. (Durak-Dados, *et.al, 2020*).Three processes are required to make sauerkraut, and each is characterised by B.A.-producing microbes. Among them are *P. cerevisiae, Lactobacillus sp.,* and *Leu. Mesenteroides* (Penas,*et.al*,2017).

The production of shredding machines, silos, and transporters, as well as all the factors lowering B.A. levels in sauerkraut production, all contribute to the initial halting of contamination by monogenic bacteria from shredded cabbage. However, Kalac *et al.* also noted that amine-negative Vaccines for contamination (kalac *et.al,* 2000).Kolesarova (1995) also discovered that the number increases with pH values between 3.6 and 3.8, suggesting that pasteurization is terminated when the pH falls below 4, as at this point yeast activity, such as P. cerevisiae, commences, increasing the amount of bacteria. (kolesarova *et.al*,1995).Histamine to 200 mg/kg. According to Kalac *et al* findings. From a different investigation, sauerkrauts infused with One *L. plantarum* or a mixture of *L. casei, L. plantarum, E. faecium,* and *Pediococcus* species lead to the Tyramine, putrescine, and cadaverine are produced in little quantities (kalac*et.al,* 2000).

(F) Antioxidant Activity:-

The reducing power assay, 20-azino-bis (3-ethylbenzo-thiazoline-6-sulfonic acid; A.B.T.S.), and 1,1-diphenyl-2-picryl hydrazyl are antioxidant activities in the fermented foods (D.P.P.H.)Estimation The reducing power assay, 20-azino-bis (3-ethylbenzo-thiazoline-6-sulfonic acid; A.B.T.S.), and 1,1-diphenyl-2-picryl hydrazyl are antioxidant activities in the fermented foods (D.P.P.H.) (Abubakar *et.al*,2012). The Indian fermented soybean meals tungrymbai and bekang, the Indian and Nepalese fermented soybean foods kinema, and the Indonesian dish temperature are only a few examples of the many Asian soybean fermented foods that have antioxidant characteristics. mold-fermented soybean food), jang and chungkokjang (Korean fermented soybean dishes) (Shon, *et.* 2007). Thailand's thuanao, Japan's natto (Ping *et al*,2012). And China's douchi are examples of fermented soybean foods. Fermented soybean cuisine is popular in China (Wang,*et.al*,2007).*L. curvatus* (SR6) and *L. paracasei* (SR10-1) improved the antioxidant value of fermented sausage, according to (Zhang, *et.al*,2017) analysis. Yogurt (Farvin *et.al,* 2010) and kimchi have also been proven to have antioxidant activity (Park, *et.al, 2011*).

V. Nutritional Value of Fermented Dairy Products:

Sour milk, yoghurt, dahi, kumiss, acidophilus milk, and other fermented milk products, such as sour milk, yoghurt, dahi, kumiss, acidophilus milk, and other similar milk products, are in high demand due to their higher nutritional value than regular milk. If the mineral composition remains constant, the quality and quantity of sour milk fluctuates (Mehta. 2015) the fermentation of microorganisms and chemicals that occur during the biochemical reactions of sour milk determines the quality of the sour milk. Alcohol, lactic acid, antibiotics, carbon dioxide, and vitamins are among these compounds (Mehta. 2015). The biological reactions listed below can help fermented milk have a higher nutritional value:

A) Lactose hydrolysis:-

Lactose hydrolysis in milk is carried out by bacteria found in the milk. Lactose hydrolysis yields 0.6 to 0.8 percent glucose, 16 to 20 percent galactose, and 45 to 50 percent lactose, compared to a milk lactose content of 5 percent. The production of galactosidase hydrolyzes lactose. Lactic acid, which lowers the pH of the intestines and limits the growth of perishable microbes, is produced by lactose breakdown. Lactic acid is also necessary for calcium absorption and organoleptic characteristics (Dutra Rosolen *et.al,* 2015).

B) Lipolysis:-

The homogenization process reduces the size of fat globules, making them more digestible (Ye, A.; Cui, J.; *et.al,* 2017). The increase in free fatty acids induced by lactic acid bacteria causes Lipolysis to have physiological effects.

C) Vitamins changes:-

The amount of vitamins in fermented milk is determined by the bacterial culture present. By using bacteria that thrive in milk, the majority of vitamin B groups, particularly riboflavin, thiamine, and nicotinamide, are doubled, while vitamins B1, B2, and ascorbic acid are reduced by around half (Yoshii, K.*et.al,* 2019)

D) Antibacterial activity:-

The antibiotic activity of developing bacteria, such as lactobacilli in yoghurt, and other chemicals that produce antibacterial qualities, such as hydrogen peroxide, lactic acid, bacteriocins, and antibiotics, determines the bactericidal impact of fermented milk (Vieco-Saiz *et.al* 2019).

E) Mineral changes:-

Because of the fermentation process and the acid, the bioavailability of minerals in fermented milk is increased by lactic acid bacteria during and after fermentation, particularly calcium, potassium, zinc, magnesium, potassium iodide, and phosphorus. M. Garcia-Burgos and colleagues (Garcia-Burgos *et al.,* 2020)

CONCLUSIONS:

Fermented foods have been part of the human diet for thousands of years around the world due to changes in their natural form that aid improve flavour and noticeable nutritional benefits, with little information and knowledge of microbial functionality. This article may encourage microbial and biochemical changes in fermented foods in a holistic fashion that helps to comprehend the overall beneficial effect of microorganisms on fermented foods by providing an in-depth review of the alterations that may cognitively influence foods.

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