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Mental Health Improvement: The Roles of Foods and Food Scientists

***Asogwa, I. S; Eze, C. M; Nwezeh, E. A; & Ugwu, A. C**
[1]Department of Food Science and Technology,
University of Nigeria, Nsukka.

*Correspondence: ifeyinwas.asogwa@unn.edu.ng

Abstract

Mental health (MH) is a wide range of conditions that affect the mood, thinking, behaviour, emotions and social well-being of people. Mental health conditions such as depression and anxiety affect a significant number of people. It is estimated that about 300 million people suffer from poor mental health worldwide. The most common types of poor MH are depression and anxiety. Outside the traditional functions of food, studies have shown a strong link between food and mental health. Foods that improve MH are associated with the Mediterranean diet such as fruits and vegetables, whole grains, cereals, nuts, seeds and among others. Mushrooms, healthy fats, and fermented foods are other foods that improve mental health. Foods that have negative effects on MH include refined carbohydrates, highly saturated oils and excess intake of alcohol. Food Scientists have important roles to play in mental health improvement. These roles include proper handling and storage of foods, use of minimal processing methods to reduce nutrient loss, use of healthy fats/oils i.e. those rich in polyunsaturated fatty acid, and food fortifications among others. It is recommended that Food Scientists should make use of those ingredients that improve MH during food processing and at the same time reduce those that negatively affect mental health. More research on the role of foods in MH improvement and strategies for using foods to improve mental health challenges should be conducted. Food Scientists should also strive to establish strong links and collaborations with major stakeholders in the food and health sectors.

Keywords: mental health, foods, food processing, Food Scientists

Introduction

Mental health is a wide range of conditions that affect mood, thinking and behaviour. It also includes emotional, psychological, and social well-being. Mental health (MH) affects how one thinks, feels, and acts. It also determines how one handles stress, relates to others, and makes choices (National Centre for Chronic Disease Prevention and Health Promotion, Division of Population Health, 2021). MH is important at every stage of life, from childhood and adolescence through adulthood. Mental health is vital to the successful performance of mental functions resulting in productive activities, fulfilling relationships, and being able to adapt to change and cope with adversities (Firth et al., 2019). Mental illness on the other hand is the opposite of mental health.

The term "mental illness" collectively refers to all diagnosable mental disorders. Mental illness is characterized by some combination of abnormal thoughts, emotions, behaviour and relationships with others (Department of Health and Human Services,1999). Following WHO's International Classification of Diseases (ICD-10), a mental disease is a broad definition for health disorders (depression, anxiety, bipolar, eating disorders and schizophrenia) and substance use (alcohol and drug use disorders), as well as neuro-developmental disorders, including autism, attention-deficit hyperactivity disorders (ADHD) and developmental disability (WHO, 1997). The determinants of poor mental health are not only related to individual capabilities of coping with emotional challenges but also include social, political, environmental, working conditions and community support. Stress, genetics, nutrition, perinatal infections and exposure to environmental hazards are contributing factors to mental disorders. Mental health and physical health are closely linked.

Mental health and physical health are closely connected. Mental health plays a major role in a person's ability to maintain good physical health. Mental disorders, such as depression and anxiety, affect a person's ability to participate in health-promoting behaviours. In turn, problems with physical health, such as chronic diseases, can have a serious impact on mental health and decrease a person's ability to participate in mental health treatment and recovery (US Dept of Health and Human Services, n.d). It has been reported that in 2019, nearly a billion people, including 14% of the world's adolescents, were living with a mental disorder. Suicide accounted for more than 1 in 100 deaths, with 58% of suicides occurring before age 50 (WHO, 2022). The prevalence of mental health disorders has increased in both developed and developing countries. Modern populations are increasingly overfed, malnourished, sedentary, sunlight-deficient, sleep-deprived, and socially isolated. These changes in lifestyle contribute both to poor physical health and the incidence and treatment of depression (Hidaka, 2012). However, the four most common mental illnesses that cause disabilities are major depression, bipolar disorder, schizophrenia, and obsessive-compulsive disorder (Murray & Lopez, 1996). The mental health scenario in developing countries is further worsened by the high poverty levels. Significant associations between poverty indicators and common mental disorders have been reported (Patel & Kleinman, 2003),

Typically, most of these mental illnesses are treated with prescription drugs, unfortunately, many of these prescribed drugs cause unwanted side effects. For example, lithium is usually prescribed for bipolar disorder, but the high doses of lithium that are normally prescribed causes side effects that include: a dulled personality, reduced emotions, memory loss, tremors, or weight gain (Waring, 2006; Vieta & Rosa, 2007). These side effects can be so severe and unpleasant that many patients

become noncompliant and, in cases of severe drug toxicity, the situation can become life-threatening. There is, therefore, the need for alternative preventive measures or new treatment approaches such as the use of foods to tackle mental illness mostly characterised by depression and anxiety.

Over the past decade, there has been a steady increase in epidemiological studies investigating the relationships between dietary patterns and mental states. Some nutritional deficiencies correlate with mental disorders. The most common nutritional deficiencies seen in mentally ill patients are omega-3 fatty acids, B vitamins, minerals, and amino acids that are precursors to neurotransmitters (Rao et al., 2008). Therefore, foods, diets, and dietary supplements are identified as complementary and alternative medicine (CAM) approaches to mental health management (Briguglio et al., 2019). Food Scientists by their profession have critical roles to play in CAM. This paper, therefore, seeks to review the established relationships between MH and food while highlighting the roles of Food Scientists in MH improvement.

Relationship between food and mental health

In recent years, the relationships between food and mental health have gained considerable interest. Food has been recognized to affect mood depending on the availability of neurotransmitter precursors (Choi et al., 2011) and recompensing mechanisms.

Food contains macronutrients; carbohydrates, proteins and fats, micronutrients; minerals and vitamins. Any deficiency of nutrient intake sustained for a sufficiently long enough term can create physical and psychological disorders. As with any other organ, the brain is nurtured with substances present in the diet. Therefore, the nutritional properties of food impact brain functions related to mood and emotion.

Epidemiological research has observed that adherence to healthy or Mediterranean dietary patterns is associated with a reduced risk of depression and improved MH (Lassale et al., 2019). These diets include; plenty of fruits and vegetables, whole grains, potatoes, cereals, beans and pulses, nuts and seeds and olive oil. Low-to-moderate amounts of dairy products, fish, and poultry, little red meat, eggs up to four times a week, and low-to-moderate amounts of wine (Lassale et al., 2019). It has also been proved that chocolate if eaten in sufficient amounts on an empty stomach, might encourage the synthesis of serotonin (Shepherd & Raats, 2006). The neurotransmitter serotonin (or 5-hydroxytryptamine; 5-HT) is formed from the precursor essential amino acid, tryptophan (TRP) in the presence of an enzyme - tryptophan hydroxylase, which converts TRP to 5-hydroxytryptophan. Abnormal levels of 5-HT have long been involved in sleep, as well as in affective disorders such as depression and anxiety. Serotonin and tryptophan are known to promote well-being (Constantin & Fonseca 2020).

Protein intake affects brain functioning and mental health. The neurotransmitters that impact mood are made of amino acids and proteins. The neurotransmitter, dopamine is made from the amino acid tyrosine, and the neurotransmitter serotonin is made from tryptophan. The limitation of these amino acids leads to the poor synthesis of the neurotransmitters and hence to low mood, whereas the excess may lead to brain damage and mental retardation (Rao et al., 2008). Foods containing tryptophan increase serotonin levels in the brain and alter neural processing in mood-regulating neurocircuits. However, tryptophan competes with other large-neutral-amino-acids (LNAA) for transport across the blood-brain barrier, a limitation that can be

mitigated by increasing the tryptophan/LNAA ratio. The LNAA include tyrosine, threonine, methionine, valine, isoleucine, leucine, histidine and phenylalanine.

The results of an experiment that increased the tryptophan/LNAA ratio in a customised drink suggest that this can lift disposition by affecting mood-regulating neurocircuits (Kroes et al., 2014). On the other hand, excess consumption of amino acids may exacerbate brain damage. It has been confirmed that excess phenylalanine in individuals can cause a disease known as phenylketonuria which can subsequently lead to brain damage and mental retardation (Rao et al., 2008). Further experimental studies have revealed that diets lacking omega-3 PUFA lead to considerable disturbance in neural function (Sinclair et al., 2007). This is because the brain is a fat-rich organ, the lipidic brain membrane contains phospholipids, sphingolipids, and cholesterol. It has been estimated that the brain's grey matter contains 50% fatty acids that are polyunsaturated (PUFA), out of which 33% belong to the omega-3 family (Rao et al., 2008).

A deficiency in omega-3 fatty acids would naturally harm brain function. Omega-3 (n-3) PUFAs, including alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), produce n-3 eicosanoids which have anti-inflammatory action. On the contrary, PUFAs, such as linoleic acid and arachidonic acid, produce n-6 eicosanoids which are generally pro-inflammatory (Schmitz & Ecker, 2008). Clinical and epidemiologic studies suggest that inadequate dietary n-3 polyunsaturated fatty acids (PUFA) may increase predisposition to several psychiatric disorders, particularly depression (McNamara & Carlson, 2006).

Western-style diets are low in omega-3 fatty acids, including the 18-carbon omega-3 fatty acid alpha-linolenic acid found mainly in plant oils, and DHA, which is found mainly in fish (Innis, 2008). Compelling population studies link high fish consumption to a low incidence of mental illness; this lower incidence rate has proven to be a direct result of omega-3 fatty acid intake which is sufficient in fish oils (Reis et al., 2006; Tanskanen et al., 2001). One to two grams of omega-3 fatty acids taken daily is the generally accepted dose for healthy individuals, but for patients with mental illness, up to 9.6 g is safe and efficacious (Von Schacky, 2006).

Depressive symptoms are the most common manifestation of micronutrient deficiency such as folate (vitamin B_9). Patients with depression have 25% lower blood folate levels than healthy subjects. Folic acid deficiency causes serotonin levels in the brain to decrease. Psychiatric patients with depression have much higher rates of folic acid deficiency than the general public (Williams et al., 2005). Vitamins B_6 and B_{12}, among others, are directly involved in the synthesis of some neurotransmitters (Rao et al., 2008). Supplementation with cobalamin (B_{12}) improves cerebral and cognitive functions and preserves the integrity of the myelin sheath of the nerve fibres (Rao et al., 2008). Individuals suffering from a lack of selenium are more anxious, irritable, hostile, and depressed than their non-lacking counterparts (Nirav, 2013).

Foods that Promote Mental Health Wellness

Mushroom: Mushrooms belonging to species of Termitomyces, Pleurotus, Lentinus, Lenzites, Trametes, Ganoderma, Pycnoporus, Coriolopsis, and Calvatia have been reported to be used in folk medicine in West Africa (Barros et al., 2018). Numerous studies have provided insights into the neuroprotective effects of medicinal mushrooms, which are attributed to their antioxidant, anti-neuroinflammatory, cholinesterase inhibitory and

neuroprotective properties (Badalyan & Rapior, 2021; Lew et al., 2020). Mushrooms are rich in glutamic acid, an amino acid which also acts as a neurotransmitter. They are also the highest dietary source of amino acid, ergothioneine; an anti-inflammatory substance which cannot be synthesized by humans (Kalaras et al., 2017). It has been shown that ergothioneine can help lower the odds of people developing schizophrenia, bipolar disorder and depression. Some mushrooms known as "magic mushrooms", naturally contain psilocybin, a hallucinogenic substance that may be as active as an antidepressant (Brown, 2021). Another possible influence may be the presence of potassium. Some research links potassium to a reduction in anxiety (Brown, 2021).

Dark, leafy vegetables: Vegetables like kale, spinach, broccoli, lettuce, asparagus, beetroot, savoy cabbage, green peas, fresh parsley, and cauliflower are part of a healthy diet loaded with vitamins and minerals like folate, vitamin C, B_3, B_6, magnesium, and zinc, and are critical to physical and mental functions (Kaplan et al., 2007). Antioxidants such as vitamin C and carotenoids play a pivotal role in protecting the body against oxidative stress, which is responsible for the causation and progression of neurodegenerative diseases, atherosclerosis, some cancers, and some forms of depression (Irshad & Chaudhuri, 2002).

Nuts and legumes: Foods like walnuts, almonds, beans, and lentils are staples of healthy eating. They are loaded with micronutrients such as folate, zinc and magnesium, healthy fats, protein, and fibre, which are linked to the reduction of anxiety and depression. The production of neurotransmitters requires nutrients (amino acids, minerals and B vitamins) found in the above-mentioned foods (Elena-teodora & Sandra, 2020).

Healthy fats: These refer to polyunsaturated fatty acids which have a positive linear relationship to high-density lipoprotein when synthesized in the liver. The main sources of such fats include oily fish, avocado and extra virgin olive oil among others and are a major part of the Mediterranean diet. The presence of polyunsaturated fatty acids confers cardio-protective benefits to the diet (Owen et al., 2000). These high PUFA fats also contain phenolic compounds which have antioxidant and anti-inflammatory properties that could help prevent symptoms of depression and elevate the mood. Dysregulated lipid metabolism and low dietary consumption of n-3 PUFAs have been implicated in neuropsychiatric diseases, encompassing specific domains including development (Milte et al., 2011; Veena et al., 2010); mood (Lin et al., 2010; Riemer et al., 2010); psychosis (Amminger et al., 2011; Evans et al., 2003); suicidal behaviours (Sublett et al., 2006), and neuro-inflammation (Kiecolt-Glaser et al., 2007; Calder, 2006).

Fermented foods: Fermentation is an ancient practice that continues to the present day. Its application in food processing is a means to provide palatability, nutritional value, preservative, and medicinal properties. In recent years, researchers have discovered many ways in which consuming fermented products affect our intestinal microbiota. For example, fermentation-enriched bioactive peptides derived from fermented products such as yoghurt, sauerkraut, and pickles may have anti-inflammatory effects, improve glycemic control antioxidants and reduce high blood pressure (Selhub et al., 2014). Fermented foods also have a beneficial effect on endotoxins called lipopolysaccharide, large molecules that are found to be particularly important in depression. The nutrients from fermented foods also could lead to improved

neurotransmitter and neuropeptide production in the brain thereby improving moods and mental well-being (Selhub et al., 2014). Controlled fermentation may often amplify the specific nutrient and phytochemical content of foods, the ultimate value of which may be associated with mental health. Microbes (for example, Lactobacillus and Bifidobacteria species) associated with fermented foods may also influence brain health (Selhub et al., 2014).

Foods that could cause poor mental health

Ultra-processed foods: Ultra-processed foods are formulations of several ingredients that, besides salt, sugar, oils and fats, include food substances not used in culinary preparations, in particular, flavours, colours, sweeteners, emulsifiers, and other additives used to imitate sensorial qualities of unprocessed or minimally processed foods and their culinary preparations or to disguise undesirable qualities of the final product (Costa et al., 2015). The ultra-processing of foods depletes their nutritional value and also increases the number of calories as ultra-processed foods tend to be high in added sugar, saturated fats and salt, while low in protein, fibre, minerals vitamins and phytochemicals (Hecht et al., 2022). Poor dietary quality is well-established as a potentially modifiable risk factor for mental disorders (Marx et al., 2017; Marx et al., 2021). A meta-analysis of prospective studies has demonstrated that greater ultra-processed food intake was associated with an increased risk of subsequent depression (Lame et al., 2022)

Results of a meta-analysis study conducted by Hafizurrachman et al. (2021) also indicated a significant positive association between the frequency of junk food consumption and symptoms of mental health problems. Polat et al. (2014) revealed that frequent junk food consumption leads to an increase in testosterone and estrogen production, which might cause specific problems, including stress triggers. In a study of children and adolescents, consuming fast food, sugar and soft drinks was associated with a higher prevalence of diagnosed attention deficit/hyperactivity disorder (Ríos-Hernández et al., 2017).

In addition to physical health risks, diets with a high glycaemic index and load (e.g diets containing high amounts of refined carbohydrates and sugars) may have a detrimental effect on psychological well-being by increasing the risk of depression and anxiety. High dietary glycaemic load, and the resultant compensatory responses, could lower plasma glucose to concentrations that trigger the secretion of autonomic counter-regulatory hormones such as cortisol, adrenaline, growth hormone, and glucagon (Ludwig, 2020; Seaquist et al., 2013). Findings showed that such counter-regulatory hormones may cause changes in anxiety, irritability, and hunger (Towler et al., 1993). Consumption of high-sugar, low fibre and high-fat diets has also been linked to the incidence of obesity. Mounting evidence reveals that the psychiatric consequences of obesity stem from poor diet, inactivity, and visceral adipose accumulation. Resulting in metabolic and vascular dysfunction, including inflammation, insulin and leptin resistance, and hypertension, which have emerged as key risks to depression and anxiety development (Milaneschi et al., 2019; Zhao et al., 2011).

Caffeine: Caffeine is the most commonly consumed central nervous system stimulant worldwide (Evans et al., 2020). It is most often consumed orally and absorbed in the gastrointestinal tract. It quickly reaches the brain because of its ability to pass through the blood-brain barrier, but it is equally distributed through the body's total water and stays in similar concentration throughout the body (Maisto et al., 2011). Caffeine has "mental activating" properties,

increasing alertness and energy and reducing sleepiness and fatigue (Fredholm et al, 1999; Smith, 2002). These effects contribute to increased performance in some contexts, being particularly apparent in situations of low alertness, such as early morning sleep deprivation, and when sustained performance is demanded. In addition, increased dopaminergic activity induced by caffeine can have positive effects on mood, cognition, effort-related behaviour, and executive functions, but this effect may, on the other hand, promote mania (or mood instability) and psychosis (Lara, 2010).

Behaviour and mood symptoms linked to psychiatric disorders have also been associated with caffeine consumption. Caffeine inhibits adenosine receptors in the central nervous system, mainly in the hippocampus, amygdala, and prefrontal cortex (locations with high concentrations of these receptors that are associated with emotion, cognition, and motivation), which might play a role in the association between depression and caffeine consumption (Cappelletti et al., 2015; Iranpour et al., 2018; López-Cruz et al., 2018). Additionally, accruing a sleep debt of two hours or more has been linked to increased melancholic symptoms, and depression was considered to be an affective symptom of sleep debt (Regestein et al., 2010).

Alcohol: Alcohol also has been associated with basically all mental disorders (Kessler et al., 1997), although the causality of these associations is not clear. Thus, mental disorders may be caused by alcohol use disorders (AUDs) or alcohol use. AUDs may be caused by other mental disorders, or third variables may be causing both AUDs and other mental disorders (Rehm, 2011). People often think of alcohol as a mood elevator, but it's a depressant. More so, alcohol increases anxiety symptoms the morning after drinking, particularly after overindulging (North West Primary Care, 2022). In addition, alcohol reduces the quality of sleep, which could induce or worsen stress and other forms of psychological distress.

The roles of Food Scientists in mental health improvement

Food Science is a multidisciplinary field that deals with the application of basic science and engineering to study the fundamental, physical, chemical and biochemical nature of foods and the principles of food processing. It is also concerned with the use of information generated by the science of food, in the selection, preservation, processing, packaging and distribution as it affects the consumption of safe, nutritious, wholesome foods (Okaka, 2010).

Based on the established association between food and MH, Food Scientists have significant roles to play in mental health improvement since they are involved in every step in the food supply chain; from farm to fork. Activities of Food Scientists could either improve or decrease critical nutrients and phytochemicals that boost mental health or cause high amounts of detrimental nutrients thereby ultimately affecting mental health. Food Scientists should therefore incorporate those handling, processing and preservation methods and ingredients that improve mental health during food processing while at the same time reducing those that negatively affect mental health. The strategies that could be employed to achieve these include:

Proper handling and storage of foods

Once food has been harvested, gathered or slaughtered, enzymes and bacteria become active in this food which causes it to deteriorate in texture and composition until it eventually becomes unfit for consumption. Fruits and vegetables continue to respire after harvest. During this process, they inhale oxygen and give out carbon dioxide as if they are living entities. This action leads to

the breaking of the stored organic materials into simple end products. In this process, energy is released in the form of heat. The loss of stored food reserves during respiration means hastening the senescence, reduced food value, loss of flavour, a quality particularly sweetness and loss of salable dry weight (Kader, 2002).

Handling starts immediately after harvest to conserve quality and nutrients. Postharvest handling is the stage of crop production immediately following harvest, including cooling, cleaning, sorting and packing. The moment a crop is removed from the ground or separated from its parent plant, it begins to deteriorate. The most important goals of postharvest handling are keeping the product cool, avoiding moisture loss and slowing down undesirable chemical changes, and avoiding physical damage such as bruising, to delay spoilage (Pokhrel, 2020) A poor-quality raw material will ultimately produce a poor quality finished product. Good post-harvest practices have a strong correlation with certain nutrients and phytochemicals in fruits and vegetables. It has been reported that all treatments that delay fruit ripening, maintain fruit quality and increase fruit life also increase antioxidant capacity, ascorbic acid, phenolics, tannins and flavonoids contents and decrease compounds associated with fruit colour such as anthocyanins, carotenoids and lycopene (Galal, 2022). Hanafy-Ahmed et al. (2008) also reported that lower temperatures maintained vitamin C content, while it decreased with increasing storage temperature. Food Scientists have the responsibility of conserving the quality of foods from harvest to the final consumers; they should therefore ensure that proper handling and storage methods are employed throughout the food supply chain.

Use of minimal processing techniques

Minimal processing involves the use of mild technologies that cause negligible influence on the quality attributes of foods during their storage or shelf life. It is a technique which allows the least physicochemical, oxidative and mechanical damage to the food products (Bansal et al., 2015). The aims of minimal processing include: (i) to make the food safe chemically and microbiologically, (ii) to retain the desired flavour, colour and texture of the food products, and (iii) to provide convenience to the consumers (Allende et al., 2006).

Fruits and vegetables are prone to microbial spoilage since these are composed of enzymes, pectin and near acidic pH, and high water activity (González-Aguilar et al., 2010). Minimal processing applied to maintain their shelf life are grading, sorting, washing, peeling, chopping and shredding. It is important to avoid harsh washing and use disinfectants during washing. This inhibits the activities of the enzymes present in fruits and vegetables such as polyphenol oxidase, polygalacturonase, and lipooxygenase. These enzymes play an essential role in initiating the oxidation process and are also responsible for spoilage in the cases of cut surfaces for diced or sliced fruits and vegetables (Vasudha et al., 2015).

For animal foods, non-thermal processing, such as high hydrostatic pressure, pulsed electric fields (PEF), oscillating magnetic fields, use of irradiation, and use of natural antimicrobials should be applied to animal-based food products (i.e. tender meat, fish, and seafoods). These treatments can help maintain the texture, flavour and taste of the foods and at the same time reduce nutrient loss.

Another strategy for achieving minimal processing is the use of hurdle technology. Hurdle technology usually works by combining more than one processing approach as opposed to the use of one approach which may prove to be too severe on the nutrients. Such approaches can be thought of as "hurdles". The right combination of “hurdles” can ensure that all

pathogens are eliminated or rendered harmless in the final products (Tavman et al., 2014) as well as achieving considerable nutrient conservation. Hurdle technology acts by exhausting bacterial cells as each hurdle that is applied requires the cells to use energy to maintain their internal pH, and osmotic pressure and keep toxic molecules out. (Brendan et al., 2011). Asogwa et al. (2018) employed the hurdle technology to extend the shelf life of soymilk by the combination of blanching, steaming, and use of natural and chemical preservatives.

Use of frying techniques that reduce oil uptake

Deep-fat frying is one of the conventional and most common operations in the preparation of a variety of fried foods, which is used worldwide to create desirable flavours and textures in foods (Bouchon et al., 2003; Zamani-Ghalehshahi & Farzaneh 2021). The advantageous sensory characteristics of most deep-fried foods derive from the formation of a composite structure that provides a crispy, porous, oily outer layer and a moist, cooked interior (Liu et al., 2020; Moreira, 2007). When food absorbs fat, it can change the composition, texture, size, and shape of the food, resulting in a loss of nutrients, specifically vitamins (Marciniak-Lukasiak et al., 2019).

There is growing interest in methods that could minimize oil uptake and reduce the fat content of fried foods. This is because the consumption of high-fat foods has been linked to obesity and other health challenges. An elevated Body Mass Index (BMI) is predictive of a chronic course of depressive and anxiety symptoms (Gariepy et al., 2010). A similar positive relationship between obesity and heightened odds of an anxiety disorder or anxiety symptoms (e.g., dread, unease) by 30% and 40%, respectively has been reported (Opel et al., 2021; Rapuano, 2020). Studies have shown that eating a diet high in saturated fats might make depression more likely. To this end, rodent research has revealed that a prolonged high-fat diet elicits metabolic dysfunction and increases anxiety and depressive-like behaviours (Sivanathan, *et al.,* 2015).

Frying methods that help to reduce oil uptake include:

a. Vacuum frying: Vacuum frying is a deep-frying process, which is carried out in a closed system, under pressures well below the atmospheric pressure levels preferably lower than 7000 Pa, thereby making it possible to reduce the boiling point of water substantially, and consequently, the frying temperature. The low temperatures employed and minimal exposure to oxygen in the vacuum frying process account for most of its benefits, which include nutrient preservation (Da Silva and Moreira, 2008), oil quality protection (Shyu *et al*, 2005) and reduction of toxic compound generation (Granda *et al,* 2004). It is an effective method to produce snacks with low oil content and a characteristic texture and flavour.

b. Air frying: Air frying is a new technique to get fried products through direct contact between an external emulsion of oil droplets in hot air and the product in a frying chamber. The product is constantly in motion to promote homogeneous contact between both phases. In this way, the product is dehydrated and the typical crust of fried products gradually appears. The amount of oil used is significantly lower than in deep oil frying giving, as a result, very low-fat products. In a study to compare the oil content of chin-chin a local snack food, Okoye et al. (2021) reported a fat content of 15.03% and 41.47 % for air-fried and deep-fried samples respectively.

c. Food coating: Edible coatings are currently used as viable alternatives for frying since these substances adhere to the product and form an external barrier that prevents the absorption of fat during immersion frying

processes (Jiang *et al.,* 2021). Asogwa et al. (2020) used gum extracted from *Prosopis africana* (*okpeye*) seed coat waste to coat plantain chips before frying, they reported a significant decrease in oil uptake as gum concentration increased.

d.Inter-esterification: The inter-esterification process rearranges the distribution of the fatty acids in oils either chemically or enzymatically within and between the triglycerides. This process brings about alteration in the distribution of fatty acids with the fat without changing their composition. One current application of this process is in the production of trans-free or low-trans fats spreads, margarine, and shortening. Several human studies have shown no significant effects of inter-esterified fats on blood lipid parameters (Hunter, 2001).

Fortification and Enrichment of Processed Foods

As already highlighted earlier many of the micronutrients like foliate, and the B vitamins have been linked to improved mental health. Heseker *et al.* (1990) reported that low vitamin B_1, ascorbic acid and folate status was associated with poor mood. Thiamine supplementation significantly improved Hamilton Anxiety Rating Scale, increased both appetite and general well-being, and reduced fatigue in patients with generalized anxiety disorder. Food scientists must therefore ensure that processed foods contain critical micronutrients and that those lost in the course of food processing are replaced or even boosted.

Food fortification is defined as the process of adding critical vitamins and minerals to commonly consumed foods during processing to improve their nutritional value (Olson et al., 2021). It is an important strategy for the prevention and control of micronutrient deficiencies. It is a safe and cost-effective strategy. Food enrichment on the other hand is a practice of replacing nutrients lost during food processing. Food processing techniques such as enrichment and fortification can boost the levels of essential nutrients in foods. Some examples are the fortification of margarine and vegetable oils with vitamin A, iodization of salt, iron-fortified infant cereals, fortification of milk with vitamin D, fortification of wheat flour with folic acid and enrichment of cereals with B vitamins. Even though these strategies are used to prevent or control micronutrient deficiencies, the improved nutritional status of those foods could also improve mental health. A strategy to fortify foods with micronutrients associated with mental health such as foliate, selenium etc., should also be advocated by Food Scientists.

Conclusion

This paper has highlighted the relationship between food and mental health. It has been observed that an individual's diet go a long way to determine his or her mental health. Among all the known diets eaten globally, the Mediterranean diet has been confirmed as the best diet for mental health promotion and protection. Food Scientists play crucial roles in the food and mental health nexus as they are involved in the farm-to-fork continuum comprising all stages of the food supply chain. The roles of Food Scientists involve employing techniques that conserve and improve critical nutrients and phytochemicals. Such techniques include proper handling and storage of foods throughout the food supply chain; minimal processing techniques, and techniques that reduce the oil content of fried foods. Other strategies include the use of the interesterification method in fat modification, food fortification, supplementation and enrichment.

Recommendations

Having established the crucial role of foods and food scientists in mental health improvement, it is recommended that;

1. Food Scientists should accelerate research targeted at the nutritional profiling of local foods and the effects of food processing on the nutrients.
2. They should also speed up efforts on establishing a link between food (especially local foods) and mental health.
3. Food Scientists should also build linkages with relevant stakeholders such as food industries, food vendors, governmental and non-governmental agencies, food regulatory bodies etc to facilitate the transmission of research findings to the community.

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