

THE EFFECT OF FOOD ON MENTAL HEALTH

O efeito dos alimentos na saúde mental

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Abstract

Food influences to a great extent our disposition whereas our mood dictates our cravings and the type of nourishments we choose. Emotions affect eating while the nutritional properties of food impact on brain functions related to mood and feelings. The dietary choices are a complete and complex circuit. Provided we influence one option, the other will follow suit, as increasing evidence has shown that the food choices have a positive impact on several mental disorders. In this research paper we have tried to show that nutritional deficiencies have been proved to negatively impact on the mental sanity and that, consequently, specific nutrients can contribute to the alleviation of mood and mental disorders. Specific nutrients can affect cognitive processes and emotions, whereas the lack of vitamins, fatty acids, minerals and some macronutrients (proteins, carbohydrates and lipids) may contribute to aggravating a poor psychological state. Among the most common nutritional deficiencies seen in mental disorder patients are those of omega-3 fatty acids, B vitamins, minerals, and amino acids that are precursors to neurotransmitters: tyrosine to dopamine, tryptophan to serotonin. Serotonin and tryptophan are known to promote well-being and their production is triggered by carbohydrate rich foods. Carbohydrates have been found to affect mood and behaviour. Inadequate dietary n-3 polyunsaturated fatty acids (PUFA) may increase predisposition to several psychiatric disorders, particularly depression. Anxiety, depression, and autism spectrum disorders have been linked to functional Gastro-Intestinal tract (GI) disruptions, whereas GI disease are often determinant for psychological comorbidities. Altered gut microbiota composition, in particular a less diversified one, has been associated with stress as well. Showing more attention to the daily food and bringing the right nutrients in the proper amounts may enhance our mood.

Palavras-chave: *Alimentos; Nutrientes; Saúde Mental, Emoções.*

Key-words: *Food; Nutrients; Mental Health, Emotions.*

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INTRODUCTION

While food and diet are known to deteriorate or improve physical conditions, it is only logical that the psychological health is also affected by what we eat, especially by what is missing from our nourishment.

Are disorders such as anxiety and depression influenced by what we consume? Or, once installed, can they be alleviated by a better nutrition? Recent studies have shown that nutritional deficiencies do not only affect our physical condition but also our mental sanity (Lakhan & Vieira, 2008; Rao, Asha, Ramesh & Rao, 2008; Hidaka, 2012; Kroes et al., 2014; McNamara, 2009; Levant, 2013; Innis, 2008; Benton, Haller, & Fordy, 1995; Banerjee, 2014; Anderberg, 2016; Sánchez-Villegas et al., 2009).

An increasing body of research has shown that the prevalence of mental health disorders has amplified in developed countries in correlation with the deterioration of the diet and consequently nutritional deficiencies are associated with some mental disorders. Among the most common nutritional deficiencies seen in mental disorder patients are of omega-3 fatty acids, B vitamins, minerals, and amino acids that are precursors to neurotransmitters (Lakhan & Vieira, 2008).

Specific nutrients can affect cognitive processes and emotions, whereas the lack of vitamins, fatty acids, minerals and some macronutrients, in particular proteins, may contribute to aggravating a poor psychological state.

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Modern world mental disorders

According to World Health Organisation (WHO) (2019), mental disorders “are generally characterized by some combination of abnormal thoughts, emotions, behaviour and relationships with others.” These affect the quality of life of people and some might appear in early adolescence. The determinants are not only individual capabilities of coping with emotional challenges, but also social, political, environmental, working conditions and community support. The WHO also confirms that stress, genetics, nutrition, perinatal infections and exposure to environmental hazards are contributing factors to mental disorders.

According to WHO sources, “around 1-in-7 people globally (11-18 percent) have one or more mental or substance use disorders. Globally, this means around one billion people in 2017 experienced one.” In accordance with WHO’s International Classification of Diseases (ICD-10) situation, 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 neurodevelopmental disorders, including autism, attention-deficit hyperactivity disorders (ADHD) and developmental disability.

The prevalence of mental health disorders has increased in developed countries in correlation with the deterioration of the Western diet. “Modern populations are increasingly overfed, malnourished, sedentary, sunlight-deficient, sleep-deprived, and socially-isolated. These changes in lifestyle each contribute to poor physical health and affect the incidence and treatment of depression” (Hidaka, 2012).

It is not clear yet whether poor nutrition, as a symptom of sadness, anxiety or depression, causes nutritional deficiencies or primary micro and macronutrients shortages produce mental health disorders that, in both cases, only enforce the symptoms of these illnesses (Rao et al., 2008).

The relationship between food and mood

It is not only the effect of food on the mood that requires our attention but also how the state of our mind influences the food choices. Emotions do affect eating. Like in a loop, the food influences the mood, which, in return, has an impact on the food choices that eventually will again improve or worsen the disposition – a circle that needs to be understood in order to better manage the mental health.

How does the food affect our mood?

Food is any natural or processed product/substance that serves as nurture for maintaining life, sustaining growth, vital processes and furnishing energy, according to standard definitions (Encyclopaedia Britannica). From a nutritional point of view, food contains macronutrients – carbohydrates, proteins and fats, and micronutrients – minerals

and vitamins (Mahan, Escott-Stump, & Krause, 2008). Any imbalance sustained on a sufficiently long enough term can create physical and psychological disorders.

As any other organ, the brain is nurtured with substances present in the diet. Therefore, the nutritional properties of food impact on brain functions related to mood and emotion. Food may spark rapid emotions by sensory stimulation such as taste, savour and smell, or relief of hunger, but it can influence mood by slower changes in brain chemistry as well (Shepherd & Raats, 2006).

Eating leads to widespread opioid release in the brain, likely signalling feelings of satiety and pleasure. A study revealed that a significant amount of endorphins is released in the entire brain after eating the pizza and, surprisingly, even more are released after the consumption of the tasteless nutritional drink. The magnitude of the opioid release was independent of the pleasure associated with eating (Tuulari et al., 2017).

A first association of food and mood that comes into one's mind is the one about coffee and chocolate. It is a popular belief that a bit of chocolate can give us a boost of happiness and improve the mood, while a sip of coffee energizes and makes us more alert. The excitants caffeine and theobromine, along with the sweet taste and some psychological mechanisms contribute to enhancing the disposition, however, it has also been proved that chocolate, if eaten in sufficient amounts on an empty stomach, might encourage the synthesis of the 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. 5-HT has long been involved in sleep, as well as in affective disorders such as depression and anxiety (Shepherd & Raats, 2006). Serotonin and tryptophan are known to promote well-being (Rao et al., 2008).

Carbohydrates

These brain chemicals' production (5-HT and TRP) is triggered by carbohydrate rich foods. Carbohydrates have been found to affect mood and behaviour. They are the macronutrients that trigger the release of insulin in the body, a hormone which enables the transformation of glucose into energy at the cellular level, and helps with facilitating the entry of tryptophan into the brain (Rao et al., 2008).

Sugars, especially sweets, can provide an immediate but short lasting effect on the mood, nevertheless, it is rather recommended the consumption of low glycaemic index (GI) foods such as fruits and vegetables, and complex carbohydrate foods - whole grains, pasta, which bring a moderate but more enduring effect on brain chemistry, mood, and energy level (Rao et al., 2008).

Proteins

Protein intake, due to the containing amino acids, also affect the brain functioning and mental health. The neurotransmitters that impact mood are made of amino acids – dopamine from tyrosine, serotonin from tryptophan. The limitation of these amino acids leads to 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).

Protein in elevated proportion was associated with higher chances of depression and arousal, whereas increased carbohydrate proportion predicted less depression and more calmness. Moreover, the reduction of TRP seems to disrupt mood and to have a greater impact than increasing the carbohydrate intake (Shepherd & Raats, 2006).

Food containing tryptophan increases serotonin levels in the brain and alters 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 ratio in a customised drink suggest that this can lift disposition by affecting mood-regulating neurocircuits (Kroes et al., 2014).

Omega-3 fatty acids

The brain is a fat-rich organ and the lipidic brain membrane contains phospholipids, sphingolipids, and cholesterol. It has been estimated that 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).

Clinical and epidemiologic studies suggest that inadequate dietary n-3 polyunsaturated fatty acids (PUFA) may increase predisposition to several psychiatric disorders, particularly depression (McNamara, 2009). N-3 PUFAs - DHA and EPA - mitigate inflammation by modulating the level and length of the inflammatory response. Thus, n-3 PUFAs could contribute to antidepressant effects and/or resistance to depression through anti-inflammatory mechanisms (McNamara, 2009).

Docosahexaenoic acid (DHA, 22:6n-3) is the most abundant PUFA in the brain, representing approximately 15% of the total fatty acids in that tissue. These long-chain PUFAs are synthesized endogenously from α -linolenic acid (18:3n-3) and eicosapentaenoic acid (EPA 20n-5:3) (Levant, 2013). However, DHA and arachidonic acid (AA)- (omega 6) cannot be synthesized by mammals and they have to be supplied through the diet.

Dietary or tissue n-3 PUFAs alone do not need to cause depression in humans; however, they likely create a vulnerability that increases susceptibility to depression when the other contributing factors (specific genotypes, stressors) are also present (Levant, 2013).

1.5 to 2 g of EPA per day have been shown to stimulate mood elevation in depressed patients. However, doses of omega-3 higher than 3 g do not present better effects than placebos and may not be suitable for some patients, such as those taking anti-clotting drugs (Lakhan & Vieira, 2008).

Western 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).

Micronutrients

Depressive symptoms are the most common manifestation of folate deficiency. Patients with depression have 25% lower blood folate (B9) levels than healthy subjects. Vitamins B6 and B12, among others, are directly involved in the synthesis of some neurotransmitters (Rao et al., 2008). Supplementation with cobalamin (B12) improves cerebral and cognitive functions and preserves the integrity of myelin sheath of the nervous fibers; (Rao et al., 2008).

Supplementation of nine vitamins, in excess, for 1-year improved mood in all subjects, according to a study. Moreover, these changes in mood were recorded after a year, even though the blood levels reached a plateau after 3 months. The mood improvements were predominantly correlated with vitamin B1, B2 and B6 (Benton et al., 1995).

Table 1 | *Connection between essential nutrients (vitamins and minerals) and affective disorders (Adapted from Holford, 2007).*

Nutrient	Effect of deficiency	Food sources
Vitamin B1	Poor concentration and attention	Wholegrains Vegetables
Vitamin B3	Depression	Wholegrains Vegetables
Vitamin B5	Poor memory Stress	Wholegrains Vegetables
Vitamin B6	Irritability Poor memory Stress	Wholegrains Bananas
Vitamin B12	Depression Confusion Poor memory Psychosis	Meat Fish Dairy products Eggs
Vitamin C	Depression	Vegetables Fresh fruit
Folic acid	Anxiety Depression Psychosis	Green leafy vegetables
Magnesium	Irritability Insomnia Depression	Green vegetables Nuts Seeds
Selenium	Irritability Depression	Wheat germs Brewer's yeast Liver Fish Garlic Sunflower seeds Brazil nuts Wholegrains
Zinc	Confusion Blank mind Depression Loss of appetite Lack of motivation	Oysters Nuts Seeds Fish

Alcohol

Another obvious association is that of alcohol and mood. The effect of alcohol on mood is undeniable. Alcohol has long been perceived to provide a temporarily relief of negative emotions, and to briefly increase pleasure and relaxation. A major study - Global Drug Survey (GDS) - that interviewed 30,000 of 18-34 year-olds from 21 countries, has

examined the link between the type of alcohol (spirits, red and white wine, beer) and the reactions it triggers in consumers: feeling energised, relaxed, sexy, confident, tired, aggressive, ill, restless and tearful, thus showing the complexity of the effects that the consumption of drugs has upon the temperament of a person (Ashton, Bellis, Davies, Hughes, & Winstock, 2017).

At low doses, ethanol is possibly useful, acting to depress brain function, very much in the style of an anaesthetic and sparking feelings of relaxation and good mood. Alcohol consumption affects neurological pathways that impact the dopaminergic, serotonergic, γ -amino butyric acid (GABA) and glutamate pathways, enhancing reward, arousal, and addiction circuits (Banerjee, 2014).

Hunger

On the other hand, hunger has proved to induce affective changes of mood, perceptions and reactions. This happens mainly because the glucose levels trigger the release of hormones that may bring along certain emotional dispositions.

The idea that *hunger* can impact emotional experiences and behaviours is coined with the informal “*hangry*”, defined by the Oxford Dictionary as feeling “bad tempered or irritable as a result of hunger”. Hangry, a pun word stemming from the combination of “hungry” and “angry,” characterizes a person’s temper which turns irritable, impatient and annoyed by the physical absence of food and the organic sensation of hunger.

A scientific explanation links mood changing to the levels of blood sugar. Individuals cannot regulate their feelings without sufficient blood glucose, and in a glucose depleted state they tend to be more impulsive, punitive, and aggressive (Anderberg, 2016).

When blood sugar drops, ghrelin, the metabolic hormone that signals hunger, triggers a cascade of hormones, which act on the sympathetic nervous system, in turn inducing unpleasant, highly arousing affective bodily changes. When the blood sugar falls, the hormones cortisol and epinephrine are released in an attempt to raise it back to normal, and another hormone Neuropeptide Y helps create a hungry feeling when the body needs more food. These hormones happen to lead to irritability and are linked to aggression (Naftulin, 2018).

While some psychologists state that hunger can be experienced as a negative, high arousal state, as “hanger”, only when the context is negative (MacCormack & Lindquist, 2019), another hypothesis explains that a modified mood is the result of metabolic processes. The tryptophan can become depleted with fasting and, consequently, tryptophan depleted individuals demonstrate greater negativity (Altman, Shankman, & Spring, 2010).

Our Microbes – the microbiota

Diet has been shown to influence the gut microbiome’s impact on cognitive function. An increasing body of evidence has started to focus on the relation between the gut, the brain and the disposition.

The gut-brain axis is a bidirectional communication network that links the enteric and central nervous systems comprising endocrine, humoral, metabolic, and immune routes of communication as well. The gut-brain connection allows the brain to influence intestinal activities and the gut to influence mood, cognition, and mental health (Appleton, 2018).

The entirety of microorganisms in a particular habitat is termed microbiota, or microflora. The collective genomes of all the microorganisms in a microbiota are termed microbiome (Wang & Kasper, 2014; Hooper, Littman, & Macpherson, 2012).

The human gut microbiota is a complex community of microorganisms, which include 100 trillion bacteria, quadrillion viruses, fungi, parasites, and archaea (Hooper et al., 2012).

Anxiety, depression, and autism spectrum disorders now have well-established links to functional Gastro-Intestinal tract (GI) disruptions, whereas GI disease (e.i, irritable bowel syndrome and disease) are often determinant for psychological comorbidities (van den Elsen, Poyntz, Weyrich, Young, & Forbes-Blom, 2017). Depression is increasingly recognized as having an inflammatory component with dysbiosis triggering the so-called *inflammasome pathway* (van den Elsen et al., 2017). Fighting depression entails adopting an anti-inflammatory diet.

In the case of leaky gut syndrome, the human body produces antibodies that are in higher levels for patients with major depression, inferring there might be a connection between gut and mental health (Appleton, 2018).

Species under *Lactobacillus* (L) and *Bifidobacterium* (B) genes are particularly characterized as anti-depressants. The mechanisms that they involve include attenuation of pro-inflammatory cytokines, regulation of tryptophan metabolism and Central Nervous System neurotransmitters.

While consumption of *L. helveticus* and *B. longum* reduced somatization, depression, and anger-hostility, hospital anxiety and depression (Anderberg, 2016), gut-associated pathogens such as infection with *C. jejuni* can exacerbate anxiety (Wang & Kasper, 2014).

Altered gut microbiota composition, in particular a less diversified one, has been associated with stress as well. A solution might be balancing the gut bacteria, through diversifying the diet. Dietary formula with higher fibre contents can improve microbiome richness. Moreover, the anxiolytic strains of *Lactobacillus* and *Bifidobacterium* genera that have anti-anxiety effects often display anti-stress effects as well (Wang & Kasper, 2014).

How does the mood affect the food?

Research suggests that people eat in response to negative and to positive emotions. Emotional eaters consume significantly more food when feeling sad than happy. Moreover, when people eat emotionally, they choose sweet over salty food (van Strien et al., 2013). A positive mood increases the preference for healthy foods over indulgent foods as a tendency to project long term health objectives, while a negative mood prompts for immediate, impactful goals such as mood control, leading to greater preference for indulgent foods over healthy foods (Gardner, Wansink, Kim, & Park, 2014).

Comfort foods provide a temporary sense of wellbeing, and they make a person feel good, by transposing it into a happy past, when it was taken care of or pampered. Researchers have found that physiological and psychological needs influence the people's attraction to a specific food.

Particular foods come to be associated with the relief of distress and modify or change emotional states or feelings. This shows that mood plays a significant role in food selection and comfort foods are preferred under certain circumstances, such as when individuals are experiencing illness (Locher, Yoels, Maurer, & Van Ells, 2005). People choose to eat comfort foods when they have the blues or feel lonely (Spence, 2017). Males prefer warm, hearty, meal-related comfort foods (such as steak, casseroles, and soup), while females instead choose comfort foods such as chocolate and ice cream (Wansink, Cheney, & Chan, 2003). Sweet foods high in calories - ice cream, cookies, and chocolate, for example, elevate mood due to serotonin and opiates production (Stein, 2008).

Treatments for affective disorders

The nutritional approach has become a valid and healthier alternative to expensive anti-depressant or anxiety reducer, drugs, which normally can lead to toxicity, unwanted side effects and, due to this, to a high degree of non-compliance in mentally ill patients (Lakhan & Vieira, 2008).

Emerging evidence and research show that nutritional supplement treatment may help controlling major depression, bipolar disorder, schizophrenia and anxiety disorders, eating disorders, attention deficit disorder/attention deficit hyperactivity disorder (ADD/ADHD), addiction, and autism, these being the most common mood conditions (Lakhan & Vieira, 2008).

Depression, anxiety and other mood disorders are thought to be directly related to imbalances in neurotransmitters and their treatment usually employs substances that inhibit or stimulate the action of these chemicals. A focus on the nutritional deficiencies associated with mental disorders might show that dietary supplements can be implemented in the treatment of several disorders.

According to Lakhan and Vieira (2008), based on human pilot clinical trials, double blind and case studies, and placebo-controlled studies, depression is caused by deficiency of serotonin, dopamine/noradrenaline, γ -aminobutyric acid (GABA), omega 3 fatty acids, folate and other B vitamins, magnesium and SAM (S-adenosylmethionine). Consequently, efficient treatments should provide supplementation of tryptophan as a precursor to serotonin, tyrosine for dopamine and noradrenaline, GABA, omega 3, vitamins of B complex, magnesium, SAM.

Likewise, bipolar disorder might be triggered by lack of omega 3 fatty acids; excess acetylcholine receptors can be treated with lithium and taurine; vitamin B complex and/or Tryptophan deficiencies to be treated with corresponding supplementation; choline deficiency to be treated with lecithin.

Schizophrenia is affected by impaired serotonin synthesis (tryptophan), glycine (glycine) and/or omega 3 deficiencies.

For obsessive compulsive disorder the St John's wort supplements have proved their efficiency.

Table 2 | *Causes and treatments for common health disorders (Adapted from Lakhan and Vieira, 2008).*

Mental Disorder	Proposed Cause	Treatment
Major Depression	Serotonin deficiency	Tryptophan
	Dopamine/Noradrenaline deficiency	Tyrosine
	GABA deficiency	GABA
	Omega-3 deficiency	Omega-3s
	Folate/Vitamin B deficiency	Folate/Vitamin B
	Magnesium deficiency	Magnesium
	SAM deficiency	SAM
Bipolar Disorder	Excess acetylcholine receptors	Lithium orotate & taurine
	Excess vanadium	Vitamin C
	Vitamin B/Folate deficiency	Vitamin B/Folate
	L-Tryptophan deficiency	L-Tryptophan
	Choline deficiency	Lecithin
	Omega-3 deficiency	Omega-3s
Schizophrenia	Impaired serotonin synthesis	Tryptophan
	Glycine deficiency	Glycine
	Omega-3 deficiency	Omega-3s
Obsessive Compulsive Disorder	St. John's wort deficiency	St. John's wort

Table 3 | List of possible cause and treatments for bipolar disorder (Adapted from Lakhan and Vieira, 2008).

Proposed Cause of Bipolar Disorder	Treatment of Bipolar Disorder
Food allergies	Avoid foods that elicit an allergic response
Caffeine	Avoid coffee and other caffeinated beverages
Inhibition of lithium from alkalizing agents	Avoid alkalizing agents like bicarbonates
Vitamin B6 deficiency	100-200 milligrams/day
Vitamin 12 deficiency	300-600 milligrams/day
Vitamin C deficiency	1-3 grams taken as divided doses
Folate B6 deficiency	200 milligrams/day
Choline deficiency	10-30 grams of phosphatidyl from in divided doses
Omega-3 or -6 deficiency	500-1000 milligrams/day
Phenylalanine deficiency	Initially 500 milligrams/day; can increase to 3-4 grams/day
Tryptophan deficiency	50-200 milligrams taken as divided doses
S-Adenosyl-L-Methionine deficiency	(SAM) 800 milligrams
Melatonin deficiency	3-6 milligrams at 9 pm
Phosphatidylserine deficiency	100 milligrams with food

CONCLUSION

The factors that contribute to the development of mental disorders are complex, as detailed in this paper, and dietary awareness, responsibility and diversity should be considered for a healthy lifestyle.

The mental disorders development involves an inflammatory aspect, nutritional deficiencies, as well as gastrointestinal disturbances. The diet is a key influencer of mental health. What we eat in excess is as important as what we do not eat enough of (Jacka, 2017). A balanced and varied diet acts to prevent and preserve the well-being and integrity of the mental health.

Therefore, more attention should be given to medium- and long-term diet changes and our food consumption should focus more on complex carbohydrates, plant-based foods/fruits and vegetables containing fibres that positively influence microbial composition, on good fats (omega 3) to modulate of inflammation. In this respect, given the fact that a large prospective study has found that the Mediterranean diet has a potential protective role with regard to depressive disorders, the return to a traditional Mediterranean diet is an obvious recommendation (Sánchez-Villegas et al., 2009).

As far as supplementation for healthy people is concerned, a diverse diet should weigh more than opting for supplements, as humans do not consume nutrients in isolation and foods come with a balanced composition of macro and micro nutrients, and fibres (Jacka, 2017). However, in the wake of positive result-trials, some supplements are needed and recommended especially as treatment for mental disorders, where they can successfully replace medication that comes with side effects.

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