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NUTRITION AND THE BRAIN (J NASSER, SECTION EDITOR)

Food and Mood: the Corresponsive Effect

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Abstract

Purpose of Review The question whether food choice and eating behavior influence the mood or are influenced by the mood has been inquisitive to scientists and researchers. The purpose of this review is to support or refuse the argument that mood is affected by food or vice versa.

Recent Findings The association between food and mood has been comprehensively elucidated in this review based on several studies that include participants from different ages, cultural backgrounds, and health status. The correlation among food, mood, and diseases such as diabetes mellitus, obesity, and depression was thoroughly investigated. The effect of different foods and nutrients on the mood was further explained. It is concluded that the mood significantly affects food intake and food choices. On the other hand, food also influences the mood, which affects the diseases either positively or negatively.

Summary Appropriate food choices play a significant role in mood enhancement. Advertisement is another crucial factor that negatively affects food choices and mood and contributes to many diseases. Understanding the interaction between food and mood can help to prevent or alleviate undesired health issues.

Keywords Food · Mood;Diseases;Healthy choices

Introduction

Eating behaviors are vastly changing over the globe. There are also drastic changes in mood, feelings, happiness, and the spread of diversity and severity of diseases. The concept of food consumption and the type of food selection have changed over the past 10 years because the variety and accessibility of food choices are getting easier and more versatile. These changes can have both positive and negative effects. The relationship between mood and food is intricate. Mood can influence the foods we choose to eat. Being stressed over specific life events may result in out-of-control eating, either through overeating or eating less frequently. Specific food choices have been reported to affect human mood significantly.

Selecting healthy foods such as vegetables and fruits promotes a healthy mood and mental well-being [1]. The consumption of fruits, vegetables, salad, and dairy products has improved during the past 10 years [2, 3]. On the other hand, the establishment of fast food restaurants in workplaces and neighborhoods has led to easy accessibility and higher consumption of fast foods among different age groups [4]. The consumers' perspectives and feelings regarding the effects of food choices on their happiness and mood change have been investigated and reported by several researchers. Recent research suggests that healthy foods have mental health benefits [5, 6] and may be a lifelong investment in future well-being [7].

The aim of this argumentative review is to examine the literature selectively in order to support or refuse the dispute regarding whether mood is affected by food or vice versa. The studies mentioned were selected randomly from many scientific databases such as PubMed, Oxford, Cochrane, Embase, International Pharmaceutical Abstract (IPA), PsycINFO, and ClinicalTrials.gov. The search was conducted using combinations of keywords and specific terms including food, mood, caffeine, chocolate, sweets, protein, vegetables, fruits, water, diseases, relationship, and advertisements.

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Food and Mood: the Concurrent Association

The argument that the consumption of healthy food is linked to more contentment and well-being contradicts the common credence that foods high in fat, sugar, or calories taste better and result in more happiness. The intertwined relationship between food choices and mood status is illustrated in Fig. 1. Eaters habitually experience a natural "unhealthy = tasty" association [8] and presume that chocolate and sweets are better mood boosters than fruits or vegetables. Subsequently, consumers have to swap the anticipated pleasure of eating with the potential complications and costs that may arise when consuming such poorly nutritious and unhealthful foods.

It is evident from several studies that experiencing stress and bad emotions leads to increased consumption of unhealthy foods in some individuals (emotional eating) [9–12]. These studies report mainly on emotional eating intended to alleviate a bad or aggressive experience or as a response to tension. The mood-boosting effect itself, however, is typically not assessed [13]. Investigating the role of unhealthy foods in positive mood modulation revealed that eating such foods may enhance the mood status after a depressive mood episode but not with the normal mood and controlled eating behavior. The mood-elevating effect of these foods is also less powerful compared with the effect of normal or healthy foods [14].

Therefore, even though people may think that some unhealthy food choices provide more enjoyment and psychosomatic advantages, eating such foods does not provide better psychological benefits compared with eating other foods. The other factor that might have contributed to this misconception is the vast reliance on retrospective evaluations such as food frequency questionnaires [7, 15] and written food diaries [16] in most studies investigating the role of eating on mental health, psychological status, mood, and well-being. Self-report negatively affects the accuracy in determining whether the average intake is reliant on the ability of participants to accurately report or remember their eating episodes, which may lead to underreporting food intake, particularly of unhealthy snacks [5, 17].

A national survey of more than 12,000 Australian adults over 2 years showed that consuming fruits and vegetables increased their life satisfaction, happiness, and well-being [7]. Among different foods, vegetables had the biggest influence on the total eating happiness, followed by grain products (i.e., bread, pasta, and cereals). The third biggest source of eating-associated contentment, however, was unhealthy snacks including sweets, salty extras, and pastries [18••].

Consumption of fruits and vegetables was associated with improving stress conditions for university students, especially those with high body mass index (BMI), while sweets and chocolate were not associated with stress conditions either positively or negatively. Stress and bad mood were significantly reduced by healthy eating among students regardless of their BMI and gender [19].

Other foods have also been linked to improved mood status. Walnuts, for example, seem to improve mood and reduce the tension or anxiety for young males who do not suffer from depression [20]. This effect is attributed to its high content of antioxidants including folate, vitamin E, and omega 3 fatty

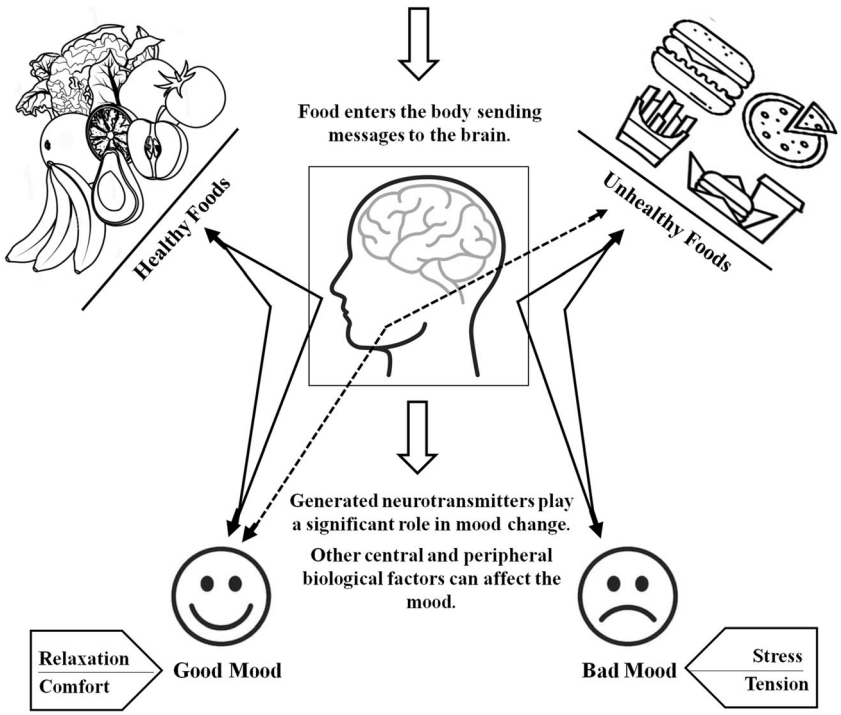

Fig. 1 The corresponsive relationship between food choices and mood status. In bad mode, the desire to unhealthy foods increases which leads to neurotransmitters imbalance. In good mode, the desire increases to both healthy and unhealthy foods. In both cases, the person needs to cut the desire to unhealthy foods and boost the mood by consuming healthy foods (i.e., fruits and vegetables)

acids with neuroprotective characteristics. Consumption of high-tryptophan proteins has been reported to help alleviate depression [21]. Tryptophan is an essential amino acid needed for normal growth in infants and children and for various metabolic processes such as nitrogen balance in adults. It is used by the human body as a precursor for the synthesis of serotonin, thought to promote healthy sleep and a good mood [22].

The counteractive effects of mood on food consumption have been studied frequently. The desire to eat and the amount of food consumed were associated with mood either positively or negatively [23]. Persons with depression symptoms usually have a change in their food preferences. They tend to consume more carbohydrates, sweets, and high-fat meals. These foods have been thought to act as mood enhancers as reported by participants in several studies. Consuming fewer carbohydrates, sweets, and coffee has been reported to reduce symptoms for depressed people [24]. Regardless of whether a person is happy or sad, the number of calories will be the same when there is no change in emotional status [25]. Hendy [26] found that the emotions and mood of students were affected by stress, which led to high consumption of calories, fatty foods, and sweets. The concept of which one affects the other; food or mood and the relationship between each of them have been divergent. Emotions and mood do not always play a significant role in the amount or type of food consumed.

Linkage Between Food, Mood, and Diseases

Diabetes

Food and diabetes are strongly interrelated. Healthy food choices and good dietary habits have a beneficial effect on diabetes mellitus (DM) status [27]. Mood can also influence insulin resistance negatively. In diabetic patients who are depressed, depression symptoms and bad mood increase their sugar readings. Table 1 (studies 1–4) summarizes the association among food, mood, and diabetes mellitus. Prinz et al. [41] studied the association among depressed mood, hypoglycemia, and disabling diabetes mellitus complications among 17,563 female German adults using the WHO-5 questionnaire. The results showed that bad mood can significantly ($P < 0.05$) increase sugar readings, especially for young women and patients who have long-standing diabetes mellitus. This effect leads to worse complications such as poor glycemic control, diabetic foot syndrome, severe hypoglycemia, coma, renal failure, stroke, and other diabetic hurdles. Furthermore, because of depressed mood, those patients would spend a longer time in the hospital [41]. Night eating in diabetic patients was linked to poor glycemic control and depressive mood among 194 adults [28]. The symptoms of night eating syndrome include disrupting eating behaviors, mood, and sleeping patterns. Improper understanding and management of this syndrome causes severe complications regarding glycemic control and glycosylated hemoglobin type A_{1C} (HbA_{1C}).

Moreover, food cravings and food addiction (FA) are significant contributing factors to higher prevalence of obesity. High BMI affects the diabetic status and glycemic controls. In another study, researchers explored how FA and impulsivity relate to body mass index (BMI) in diabetic patients [29]. Participants (334 adults) completed online surveys including Depression Anxiety Stress Scale (DASS-21), the Barratt Impulsiveness Scale (BIS-II), and the Yale Food Addiction Scale (YFAS). More than 70% of diabetic participants met YFAS criteria for FA. Participants with FA had significantly ($P < 0.001$) higher BMIs. FA and impulsivity were more prominent predictors of BMI in type 2 diabetic patients than indicators of anxiety, depression, stress, and impulsivity. The incidence of binge eating and its connection to adiposity and psychosocial functioning, mood, and quality of life (QOL) in 678 diabetic youth (mean age, 14 years; 64.9% girls) were investigated [30]. The results showed that youth with clinical and subclinical binge eating disorder had significantly higher obesity rates, higher levels of global eating disorder, depressive symptoms, and impaired QOL. In fact, food, mood, and diabetes mellitus are interlinked. Good mood and healthy food choices influence sugar readings positively. This helps the aging process and reduces the complications of diabetes mellitus. Food rich in zinc can improve mood. This can be a cofactor for insulin metabolism to maximize the amount of insulin entering the cells [31].

Obesity

Obesity (BMI ≥ 30 kg/m^2) has become a global concern leading to many health complications and increasing mortality and morbidity rates all over the world [42]. Studies show that the desire to eat and the amount of food eaten are directly linked to obesity (Table 1; studies 4–10). The results of animal and human studies revealed a reciprocal connection among food choices, mood status, and obesity. Dopamine, produced in the human body upon feeling satisfied after eating, activates joy sites in the brain. This will motivate a person to repetitively eat certain foods to enjoy this feeling of contentment, which, in turn, leads to overeating and morbid obesity [43]. Moreover, emotional eating and mood alteration can distort food choice and change food intake, contributing to obesity. Mood disorders are associated with abnormal eating behaviors. Obesity, for example, is more often accompanied by depression and anxiety [44]. Mutilation or disability in the central nervous system has been associated with obesity, which negatively affects mental and physical health [45]. It has also been proven that people with abnormal eating behaviors are more prone

Table 1 Studies showing the interrelationships between food, mood, and diseases

	Title	Sample	Methodology	Results	Reference
1	Female sex, young age, northern German residence, hypoglycemia and disabling diabetes complications are associated with depressed mood in the WHO-5 questionnaire—A multicenter DPV study among 17,563 adult patients with Type 2 diabetes	17,563 adults (55.9–71.1 years) from the multicenter diabetes follow-up registry	WHO-5 questionnaire, a screening tool for depression, was used	Depressed mood can affect sugar reading significantly ($P < 0.05$), especially for females, young age, and patients with long-duration diabetes	[28]
2	Night eating in patients with type 2 diabetes. Associations with glycemic control, eating patterns, sleep, and mood	194 adults with type 2 diabetes	Questionnaires for assessing night eating symptoms as well as eating, sleep, and depressive symptoms Glycemic control was measure by hemoglobin A1c (HbA1c)	Night eating was linked with poor sugar readings and poor control of HbA1c	[29]
3	Food addiction symptomology, impulsivity, mood, and body mass index in people with type 2 diabetes	334 diabetic adults	Online surveys including the Depression Anxiety Stress Scale, the Barratt Impulsiveness Scale, and the Yale Food Addiction Scale	Over 70% of diabetic participants met the YFAS criteria for food addiction $P < 0.001$	[30]
4	Binge eating, mood, and quality of life in youth with type 2 diabetes: baseline data from the today study	678 youth	Completed a self-report measure of eating disorder symptoms	Youth with clinical of binge eating had significantly linked with higher levels of extreme obesity, eating disorder and depressive symptoms, and impaired quality of life	[31]
5	Fast food and obesity: a spatial analysis in a large United Kingdom population of children aged 13–15	4827 subjects (48.8% males)	Data was collected using FFQ about the type and frequency for consumption of fast foods, body fat, and physical activity	The consumption of fast food associated significantly with higher obesity rate with odds ratio of 1.23	[32•]
6	The relation between obesity and depressed mood in a multi-ethnic population. The HELIUS study	21,030 persons	Cross-sectional relationships between obesity measures [MBI and waist circumference] and depressed mood (PHQ-9 score ≥ 10)	Obesity was associated with a higher risk of depressed mood among different ethnic groups. This association was stronger in the Dutch and African Surinamese populations	[33]
7	Depressive mood and obesity in US adults: comparison and moderation by sex, age, and race	44,800 respondents from 2011 Behavioral Risk Factor Surveillance Survey	Behavioral Risk Factor Surveillance Survey	Obesity is a factor for being depressed and obese women are more likely to have depressed mood than non-obese ones	[34]
8	Synergistic effects of depressed mood and obesity on long-term cardiovascular risks in 1510 obese men and women: results from the MONICA–KORA Augsburg Cohort Study 1984–1998	737 males and 773 females (45–74 years) suffering from obesity	A prospective population-based cohort study of three independent cross-sectional surveys	Obesity related to depressed mood in both males and females Combining obesity and depressed mood resulted in a relative risk to suffer from a future coronary heart disease	[35•]
9	Differential food intake and food choice by depression and body mass index levels following a mood manipulation in a buffet-style setting	154 participants grouped by depression and obesity categories	Participants read a series of vignettes that were sad (on 1 day) and neutral (on a different day), followed by a buffet to eat until full. Food intake (in grams and calories) and food choice (number of high- or low-calorie food options) were recorded	Participants who were obese and depressed had significantly greater energy intake following the sad versus happy vignette, largely due to increased intake of high-calorie foods	[36]
10	Impulse control in negative mood states, emotional eating, and food addiction are associated with lower quality of life in adolescents with severe obesity	69 adolescents aged 13–21 with severe obesity presenting for prebariatric surgery psychological evaluations	Emotional Eating Scale for children, food addiction (Yale Food Addiction Scale), and poorer weight-related QOL (Impact of Weight on Quality of Life-Kids)	Impulse control disorder (ICD) was significantly associated with poorer weight-related QOL. It was associated with lower QOL in adolescents with severe obesity	[37]
11		60 participants			[38]

Table 1 (continued)

	Title	Sample	Methodology	Results	Reference
	No calorie comfort: Viewing and drawing "comfort foods" similarly augment positive mood for those with depression		Participants viewed/drew foods high or low in fat/sugar; pre-post mood was recorded	Viewing/drawing comfort foods enhanced the mood for those with clinical symptoms of depression	
12	Fish consumption and severely depressed mood, findings from the first national nutrition follow-up study	5068 adults aged 25–74 years	National Health and Nutrition Examination Survey Follow-up Study using a 3-month FFQ and scoring the depressed mood using the Center for Epidemiologic Studies Depression Scale	Low consumption of fish led to severely depressed mood	[39•]
13	Emotional eating, depressive symptoms and self-reported food consumption. A population-based study	25- to 64-year-old men (n = 1679) and women (n = 2035)	The Three-Factor Eating Questionnaire-R18, Center for Epidemiological Studies Depression Scale, and a 132-item Food Frequency Questionnaire were used	Emotional eating and depressive symptoms affect unhealthy food choices. Depressed people consume few vegetables and fruits and a lot of sweet foods	[40]

to depression and that negatively altered mood is linked to abdominal obesity and poor diet [46, 47].

A similar link between obesity and depression has been reported in animal models [44]. Excessive consumption of fast foods was found to contribute to higher BMI and higher body fat percentage in children aged 13 to 15 years [48]. The strong and significant association between obesity and mood has been frequently reported by many researchers, as depressed mood was highly related to increased obesity rates [32•]. Obesity is globally linked to depression and both are factors leading to emotional eating disorders. Researchers further reported that young overweight and obese women had a higher chance of depression than women of normal weight. Similarly, young overweight men had more instances of depressive mood than men of normal weight [33].

In a study of 1510 obese subjects (45–74 years old), Ladwig et al. [34] found that obesity is related to depressed mood in both men and women. Studies found that people suffering from obesity and depression tend to consume energy-dense foods and exceed their caloric requirements [35•]. Bad mood is consequently associated with reducing QOL relating to obesity. Morbid obesity in adolescents was augmented with bad mood resulting in poor QOL [30]. Moreover, obesity often occurs as a result of food addiction and emotional eating, and these two factors are significantly affected by bad mood. Researchers found that impulse control disorder, the poor control of behavior under impaired mood, was significantly related to inferior weight-related QOL, and this association was arbitrated by an association between emotional eating and FA. Impulse control in negative mood was also linked to lower QOL in adolescents who have severe obesity [36].

In conclusion, the incidence of obesity is increasing among children, adolescents, and adults. This can lead to lower cognitive function, bad mood, lethargy, and inactivity. Furthermore, people with bad mood tend to increase their consumption of unhealthy foods, believing that this may make them fresh, alert, and more active.

Depression

Depression is the biggest psychological problem that affects the mood, emotion, and behavior. It affects both men and women from different cultures and backgrounds and at all stages of life. According to the WHO, more than 300 million people suffer from depression worldwide. Depression is the principal cause of disability and is a main contributor to the overall global burden of disease. Depression can lead to suicide, which is the second primary cause of death among people between the ages of 15 and 29 years. It is reported that 2% of school-aged children and 5% of teenagers suffer from depression [37] and that women are more affected by depression than men. Depression can lead to emotional eating, which can drastically affect food choices.

Depressed people who practice emotional eating consume more sweet foods, while depressed people who do not suffer from emotional eating consume less fruits and vegetables; thus, both depression and emotional eating influence food choices and increase the consumption of unhealthy foods [49]. Eating high-fat, high-sugar comfort foods such as desserts and fried food supports positive mood by increasing activity in the brain reward regions [40]. Furthermore, there is growing evidence that displaying visual images of comfort foods (high fat, high sugar) without eating is enough to increase the neural activity in brain reward regions [50] and to

support positive mood in nonclinical groups [51••]. Either viewing or drawing foods, participants always showed mood augmentation after viewing/drawing comfort foods but not with low-fat, low-sugar vegetables [51••]. Participants who had clinical depressive symptoms had the greatest post-session mood improvement after viewing/drawing comfort foods. This behavioral style is consistent with neurobiological records showing greater responsiveness in limbic and neural reward circuits associated with depression and obesity [38] when viewing high-calorie food images [50].

However, in some cases, low consumption of specific nutrients may cause depression or increase the severity of the disease itself. A clinical observation found a relationship between folate and neuropsychiatric disorder; most depressed patients have a deficiency in folate, which affects the efficacy of antidepressant drugs [52]. Furthermore, low consumption of fish in depressed men could increase the severity of depression and decrease appetite [53]. Likewise, low consumption of omega-3 sources such as fish and nuts can increase anxiety and depression. Taking omega-3 supplementation could improve mood, anxiety, and depression status [39•]. In conclusion, food can affect the mood either positively or negatively. Deficiency of nutrients such as vitamin B complex, vitamin D, vitamin C, zinc, omega-3 fatty acids, and antioxidants can drastically affect the mood, which may lead to depression in the long term. Such nutrients regulate and balance the neurotransmitters responsible for adjusting mood. These nutrients can be found in good amount in fruits, vegetables, and dairy products [54]. Some studies investigating the interrelationships among food choices, eating behaviors, and depression are illustrated in Table 1 (studies 11–13).

Foods that Can Boost the Mood

Caffeine

Caffeine is classified as a national drug that can affect the mood and mental well-being in daily life. Its role as a stimulating agent for the central nervous system can temporarily enhance the activity. Temporary caffeine deficiency in habitual consumers results in withdrawal symptoms [55]. Researchers found that caffeine intake in the morning can significantly decrease morning tension and increase performance [56]. Its significant effect in improving fatigue and increasing alertness has been observed [57]. Caffeine consumption in different doses at different times and durations can significantly change the mood and improve performance and alteration [58]. Habitual coffee drinkers have been reported to have a decreased risk of depression [59].

On the other hand, Haskell et al. [57] found no significant correlation between consuming coffee and working performance, but it slightly improves mood. However, consuming too much caffeine can lead to many side effects such as tension, nervousness, anxiety, headache, and insomnia [58, 60]. James and Gregg [61] suggested moderating the amount of caffeine consumption because they did not find any significant effects of caffeine in mood improvement. Furthermore, researchers recommended reducing caffeine consumption by men and women aged 45 years and above, as the older ages were more influenced by caffeine leading to stress and much worry [62]. Conclusively, the consumption of caffeine by adults among different cultures and ethnicities is increasing globally either hot drinks (coffee and tea) or other caffeinated beverages. Its effect on increasing activity and alertness and boosting the mood is well reported. However, moderating caffeine intake is advised due to the deleterious side effects of higher doses.

Chocolate and Other Sweets

Studies conclude that consuming sweets and sweet-tasty foods affects the mood positively, with the effect being higher in women than in men. Chocolate has a potent influence on mood, commonly mounting congenial feelings and relieving tension [63–65]. In addition to its ingredients of theobromine and caffeine, which are known to have stimulant properties, chocolate contains psychoactive chemicals that target the opioid receptors in the central nervous system (e.g., anandamides) that act at the same site in the brain as cannabis and tyramine and phenylethylamine, which act in a similar manner to amphetamine [66], making it a popular choice as an antidepressive agent [67].

Eating high-quality chocolate improves mood and increases alertness during the day [68]. Significant mood changes and reduced fatigue had been observed after 3 days of consuming chocolate [69]. Its exceptional taste and mouth feel lead to chocolate cravings due to sensory attributes when consumed [63, 64]. Researchers report that eating high-cacao biscuits or high-cacao chocolate with breakfast benefits the eaters by causing a full feeling and reducing the desire for eating throughout the morning.

However, excessive consumption of these types of foods affects the eater negatively by causing loss of control over eating sweets [70]. Overconsumption of chocolate had been associated with increased anxiety over time than moderate-to-low consumption. Some women on weight loss programs experience bad feelings and feel guilty after eating chocolate. However, regular moderate-to-low consumption was associated with increased joy and better mood [71].

The link between the mood status and consuming chocolate or high-sugar foods is further reported. Individuals with bad mood tend to increase their consumption of such foods. In a controlled trial study, Turner et al. [72] studied the influence of good mood augmentation on the consumption of chocolate chip cookies in emotional and uncontrolled eating styles

among women between the ages of 16 and 45 years of age. The respondents were randomly assigned to the control or mood augmentation condition (a comedy movie). Among individuals with controlled eating style, positive mood improvement resulted in eating 3.3 cookies (53.86 kcal) less. On the contrary, among those with uncontrolled eating, mood improvement increased the consumption by an average of 1.7 cookies more. This finding supports the idea that although people in a good mood may sometimes consume unhealthy foods, this is just a temporary advertence. However, the long-term tendency is that, in normal conditions, people in a good mood and a controlled eating style will likely choose healthy foods.

Protein and Mood

Proteins are momentous components of every human body cell where they play significant roles in DNA formation, hormone synthesis, growth, and building muscles and tissues. They are crucially needed for the anabolic mechanism, recovery, maintaining or losing weight, and reducing cardiovascular viral risk. In addition to their intrinsic physiologic functions, proteins further play psychologic roles in the human body. Protein and high-protein foods are important to reduce or prevent severely depressed mood in men [73]. Consumption of high-protein soy snacks was found to improve mood and cognitive abilities, control appetite and satiety, and enhance diet quality for adolescents [74]. Drinking the "Essence of Chicken," an Asian supplement made of important nutrients extracted from chicken meat at high temperature and characterized as fat- and cholesterol-free, for 10 days could positively affect mood, cognitive ability, and energy. It could further decrease anxiety, depression, and heart rate variability [75]. However, balanced eating is the key for health. Consuming more or less red meat than the recommended intake can increase the accessibility to depression and anxiety disorders. In a large survey of Australian women in their 20s, researchers found a significant increase in depressive symptoms among vegetarians compared with nonvegetarians (22% vs. 15%) [76]. Among 1046 Australian women, lower red meat consumption was linked to almost a doubling of risk for major depressive and anxiety disorders [77]. Among Norwegian students, nearly twice as many men and one third more women with low meat consumption have been reported to be depressed after adjustment [78]. Other studies found that diets restricting meat and poultry have no positive effects on mood as much as the diet containing meat, poultry, and fish [79]. However, increasing the consumption of fatty fish for healthy individuals who do not have depression or anxiety disorders has no effect on mood, either positively or negatively [80]. To sum up, protein is eventually needed for the human body to survive and maintain its ability to be active, with the required amount differing according to the individual conditions. Decreasing protein consumption for both genders can lead to many medical complications, bad mood, and depression. Further research is needed to confirm its link to the mood change and clarify the gender-based variations.

Vegetables, Fruits, and Mood

Vegetables and fruits are classified as foods containing micronutrients such as water-soluble vitamins and trace minerals linked to health and well-being. They further encompass high amounts of phytochemicals with antioxidant, antibacterial, and antimutagenic effects. Vegetables and fruits are consumed as fresh produce, canned, frozen, steamed, roasted, baked, fried, and pickled products. However, eating fresh vegetables and fruits rather than processed ones is linked to better mental health [81]. Due to their high nutrition value, elevated consumption of vegetables and fruits has been further associated with good psychologic heath, cognitive functions, and mood in both and women [6, 82]. Eating varied types of vegetable and fruits ensures obtaining the daily requirement of vitamins and minerals needed for maintaining health and preventing diseases. Daily consumption of various vegetables and fruits with different colors by young adults was associated with positive mood and increased creativity, curiosity, and conduciveness to happiness [83]. However, economic state may affect the purchasing decisions and narrow the selection scope of fruits and vegetables. Increasing knowledge of different preparation methods for vegetables among low-income individuals may help increase the consumption of vegetables and improve health and mood [84]. Epidemiologic studies suggest that consumption of flavonoids, found in fruits and vegetables, is associated with reduced risk depression. Flavonoids improve executive function linked to cognitive processes and consequently lessen depressionogenic cognitive processes and improve mood. In a study of children between the ages of 7 and 10 years (n = 50) and young adults between the ages of 18 and 21 (n = 21) who consumed a flavonoid-rich blueberry drink, the intervention improved their depression and played a role in their positive mood [85].

Unlike other foods, there is no restriction on eating vegetables and fruits. Healthy adults can eat as many vegetables and fruits as possible, as long as they are part of a normal diet. The main concern of overeating fruits is their natural sugar. However, despite the high sugar content of some fruits, research has consistently linked whole fruit consumption to a reduced risk of obesity and other metabolic diseases [86]. Whole fruit has built-in structures that moderate any sugar-driven health risks. The high content of both soluble and insoluble fibers helps to form a gel-like medium inside the

small intestine, which prevents a significant portion of the fruit's sugar from being absorbed during the digestive process.

Water and Mood

Water is the most essential element for life, as every single live cell needs water to function and survive. It helps create saliva; regulates body temperature; protects tissues and organs; helps excrete waste through perspiration, urination, and defecation; helps digestion and physical performance; and prevent constipations and dehydration. It further helps with nutrient absorption, weight loss, blood oxygen circulation, fighting illnesses, boosting energy, and improving cognitive functions and mood. Limited water intake ultimately affects mood [87]. Inadequate water intake by women contributed to bad mood, depression, confusion, tension, and anger. However, these mood-related symptoms affected the amount of water consumed during the day either positively or negatively [88].

Fluid deprivation is associated with dehydration, which leads to fatigue, alertness, decreased activity, decreased saliva production, and poor sleep quality [89]. Armstrong et al. [90] found that bad mood highly correlated with lower water intake. They further reported that fatigue and vigorous activity were also influenced by total water intake. Dehydration among men was associated with low energy, fatigue, anxiety/tension, bad mood, and bad memory [91]. Other researchers found no difference in depressed mood regarding how much water was consumed rather than the time of drinking. Participants drinking less water during the day suffered from thirst, low energy, and irregular sleeping habits [92].

Being attentive to the amount of water consumed each day is important for optimal health. According to the National Academies of Sciences, Engineering, and Medicine, general daily water intake (from all beverages and foods) that meets most people's needs is approximately 15.5 cups of water (3.75 L) for men and approximately 11.5 cups (2.73 L) for women. People get approximately 20% of their daily water intake from food, and the rest should be acquired from drinking water and water-based beverages. Therefore, ideal daily water consumption should be 100 oz (3.0 L) and 73 oz (2.12 L) for men and women, respectively [93].

Other Nutrients with Mood-Boosting Effects

In addition to the abovementioned foods with evidenced-based mood-modulating effects, other nutrients have been reported to affect mood status in some studies. Some micronutrients including iron, thiamine, and folic acid have emotion-adjusting roles. Iron-deficiency anemia has been linked to depressed mood, reduced attention, and increased fatigue [94]. Adequate thiamine intake was found to improve sociability, well-being, and overall energy levels. Inadequate intake of this vitamin affects mood and cognitive functions negatively [94–96].

Folic acid plays a crucial role in body health. Children and adolescents suffering from metabolic abnormalities impacting folate transport have been diagnosed with developmental delays and cognitive deterioration, as well as behavioral and psychologic problems. Similarly, adults with folate deficiency have been found to have a higher risk of neuropsychiatric disorders, depression, and even epilepsy. Numerous studies have linked folic acid supplementation in the elderly to better cognitive performance and mood status [97–99]. It is further reported that psychiatric patients often have folate deficiency due to loss of appetite caused by anticonvulsant drugs that restrain folic acid absorption [66].

Omega-3 fatty acids, such as alpha-linolenic acid (ALA), found mainly in oilseeds, as well as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) found in fish and other seafoods, have positive effects on behavior, mood, neuroticism, and impulse control [100, 101]. They have positive effects on major depressive disorder, bipolar disorder, schizophrenia, substance abuse, and attention-deficit disorder [101, 102]. Both EPA and DHA play a vital role in brain development and function [103]. Low blood levels of these acids are linked to depression, entailing a role in mood disorders [104, 105].

Advertising Food: Does It Help Enhance Healthy Eating?

In the current era of satellites and the internet, media now controls our lives, behaviors, thinking, and choices. Media and advertising have a power to control eating behaviors, nutrition habits, and food choices for different age groups. Unfortunately, the majority of today's advertisements focus on unhealthy foods such as fast foods, high-energy foods, low-dense foods, chocolate, and confectionery [106, 107]. These ads have been offering poor food choices targeting vulnerable groups such as children and adolescents. This has consequently contributed to the great increment in the global child obesity rates [108]. Fatefully, food advertising often deviates from the scientific facts on food and mental health and well-being. Studies show that although healthy foods have the potential to enhance mood, this is not often used as a key advertising message. On the contrary, advertisements for foods that can depress mood often adopt messages of happiness and well-being [109]. As a matter of fact, people of different ages, cultures, and backgrounds are significantly influenced by what they see. Hence, proper weight, BMI, healthy behaviors, and anti-obesity advertisements have the potential to change the way of choosing food, eating behaviors, and knowledge about the risk of disease, especially in overweight and obese people [110•].

Despite the drastic global increase in the number of overweight or obese infants and children [111], food-processing companies keep targeting them with improper advertising for hazardous and unhealthful products that exacerbate this obesity crisis. Various health problems may develop in obese children, including diabetes mellitus, heart diseases, cardiovascular disease, musculoskeletal disorders, and disability. Choosing healthy foods for infants and children is critical because food preferences are established in early life.

The food and beverage companies expend billions of dollars annually in promoting products targeting children and teenagers [112]. It is worth noting that 30% of all paid television advertising watched by children and adolescents is represented by food products [113]. These vulnerable groups are further targeted through social media, the Internet, and other advertising venues [114]. Most of the foods advertised are deleterious, high-caloric, unhealthy, and nutrient-poor foods, or junk foods [114].

Research showed that improper food advertising may further adversely affect the food choices and health status of children and adolescents through advocating snack foods, high-sugar/high-caloric beverages, and junk foods [115–117]. Reducing the amount of advertisements for unhealthy food targeting young people is crucially necessary. Effective tools and measures should be in place to protect children from being exposed to inappropriate food advertising. These may be attained by providing nutrition and media literacy education to encourage the consumption of healthy foods. Industry self-regulation, government legislation and regulation, and litigation should be further in place [106]. However, as money talks, education, awareness, and counter-advertising alone cannot compete with the billions of dollars spent by this industry. It is also unwise to assume that the industry will voluntarily adopt these changes. Therefore, governmental bodies must introduce clear and strict regulations and legislations to force this industry to apply effective self-regulations that will limit or prohibit such types of harmful advertising.

Conclusions and Recommendations

In conclusion, different food choices can boost or depress the mood. Mood further plays a major role in personal food choices, appetite, and the desire to eat. Healthy foods such as vegetables, fruits, protein, and nuts along with adequate amounts of water and moderate amounts of caffeine contribute to good mood. However, unhealthy food choices such as excessive consumption of chocolates, sweets, fast foods, and low-nutrient foods may contribute to the good mood too, but the effect is temporary and can adversely affect health and may lead to many chronic diseases. On the other hand, stressed individuals may show a high desire to eat unhealthy foods to enhance their mood while seeing the healthy choices negatively affecting their mood. Advertising is a potential contributor in promoting unhealthy food choices that can temporarily boost the mood and provide energy. Finally, this concept is highly complex, depending on personal mood, environmental factors, stress conditions, and food availability. The authors recommend eating a variety of healthy foods and disregarding the bad effects of media and the fake information regarding foods and mood from advertising. For specific health conditions, it is preferable for patients and caregivers to know the proper food choices to prevent the interaction between food and mood that may hinder treatment. Further research is needed to clarify such an intricate connection between food and mood status. Research questions such as how long the effect of food on the mood state can last and how food can affect disease progression in chronically ill patients should be addressed.

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Compliance with Ethical Standards

Conflict of Interest Welayah A. AlAmmar, Fatima H. Albeesh, and Rabie Y. Khattab declare they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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addressed the importance of ω3 PUFAs in the prevention and/or treatment of depression and anxiety. Recent experimental studies highlighting how ω3 PUFAs can moderate neurobiological processes involved in anxiety and depression have been covered. Potential mechanisms involved in the neuroprotective and corrective activity of ω3 PUFAs in the brain have been discussed.

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