



The Effects of Food and Food Additives on Behaviors

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Abstract

Behaviors are outward reflection of personality and is shaped by genetic and environmental factors. Nutrients, one of the environmental factors and consumed with foods, are indispensable elements for both prenatal and postnatal life to lead a healthy life at every stage of life and to demonstrate healthy behaviors. In this survey, the role of food as one of the environmental factors and the additives in them on behavior will be reviewed by taking into account several stages of life.

Keywords: Food Additive, Behavior, Food, Nutrition, Temperament, Character, Personality

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INTRODUCTION

Behavior is the entire responses of the organism against stimuli and, reflects person's temperament, character, and personality traits. Personality and character development is a complex process involving genetic and environmental factors. In this review in which the role of food as one of the environmental factors and the additives in them will be examined, first of all, relations among temperament - character - personality will be addressed then, the effects of foods and food additives on behavior will be examined taking pre-natal and post-natal periods into account.

TEMPERAMENT, CHARACTER AND PERSONALITY

Although temperament, character and personality are different concepts, they are often used interchangeably. Temperament is an inherited structural feature that changes at a very small degree throughout life. Rothbart et al. (2000), defined temperament as a biological inborn structure, and can

be formed over time being influenced by factors such as heredity, maturation and experience. Character is learned attitudes developed under the effects of environment and upbringing, therefore, it involves the traits that can be changed over time. Personality is a combination of genetic temperament and later developed character (Akiskal et al. 1983).

Allport (1961), defined personality in his classical definition as an internal process that directs behavior. Studies have clearly demonstrated the effects of biological and genetic factors that are referred as internal processes on personality. Temperament is defined as individual differences in the early period of emotional, motor and attentional responses, and in self-control, and it is indicated as a biological aspect of personality (Rothbart and Bates, 2006; Rothbart, 2007). According to Ajzen, a general way to describe human behavior is to consider stable dispositions of the individuals. The concept of "personality traits"

corresponds to these dispositions (Ajzen 1988). Since a trait cannot be directly observed, extent of the trait is predicted from overt behavior. However, not only overt behavior but also neurobiological and genetic differences between individuals give information about the personality traits (Nettle 2007). Personality traits are based on two assumptions. The first is that personality traits do not change over time, and the second assumption is that personality traits shows stability across situations (Burger 2007). Temperament is an innate structure, and personality traits develop outside of this structure (Saucier and Simonds 2006).

Personality development goes together with physical development (Cooper 1950). Behavior patterns are developed during infancy and they changed later in life with experiences. In these experiences, good nutrition is one of the most important factors for the development of a good personality (Cooper 1950). In this paper, the studies showing how much nutrition is effective on personality have been mentioned. Accurate and good nutrition from prenatal until adult life has been regarded as one of the determinants of the development of a positive personality.

RELATIONSHIP BETWEEN NUTRIENTS AND BEHAVIORS

Biological and nutritional factors and their interactions affect all of life's processes. The development of the brain and as a functional result of it behaviors are also exposed to the same effect (Rosales et al. 2009).

Genetic determinants play a key role in the development of the central nervous system. Moreover, environmental factors are also effective (Levitt, 2003; Heng et al. 2007; Hsu et al. 2007; Nakajima et al. 2007; Zeisel, 2009). In fact, child is born with learning capacity, but environmental factors determine what and how to learn. Quick and obvious changes such as brain plasticity occur in the early childhood up to the age of five, and basic cognitive and interpersonal skills are acquired (Livesay and Morgan 1991; Zelazo et al. 1996; Kochanska et al. 2001; Burrage et al. 2008).

What is the role of nutrition in this complex process? Nutrition is an environmental factor (Bryan et al. 2004), but contrary to other environmental resources such as medical care, education and experience, it can directly change the genetic structure and regulate the expression of the genetic factors that will play a role in brain development by providing specific molecules. Brain is a specific tissue and its functionality depends on the formation of electric potential and its transmission between long axonal extensions of the cells and synaptic intervals between the cells. For these functions the brain needs nutrients, such as choline, folic acid, iron, zinc, and special oils (ganglioside, sifingolipidler and dokozahegzaenoik acid-DHA-, etc.). These nutrients are vital for the development of brain (Georgieff 2007).

It has been established that protein-calorie malnutrition and the lack of trace elements have adverse effects on Central Nervous System (CNS) development and function (Morgane et al. 1992; Levitsky and Strupp, 1995; Rao et al. 2000; Lozoff et al. 2006). There are a large number of researches reporting that brain development of the animals that received too little zinc and protein during the pregnancy and breast-feeding period is adversely affected (Oteiza et al. 1990; Bennis-Taleb, 1999). There is an association between congenital brain abnormalities and DNA, RNA and protein synthesis adversely affected by zinc deficiency during pregnancy in humans too (Pfeiffer and Braverman, 1982; King, 2000).

Folate (Alpert and Fava, 1997) have reported that many nutrients such as essential fatty acids (Appleton et al. 2006) and iron (Corwin et al. 2003) play an important role in brain development and function, and can affect the child's future life, behavior and cognitive functions (Colombo et al. 2004; Zhou et al. 2006; Hibbeln et al. 2007; Gale et al. 2008; Parsons et al. 2008). It has been established that prenatal exposure to alcohol is a risk factor for cognitive deficits, stress reactivity and the behavioral problems (Streissguth et al. 1990; Sood et al. 2001; Haley et al. 2006; Sayal et al. 2007), and especially the high level of exposure has increased these risks (Streissguth et al. 1991; Fryer et al. 2007).

When viewed in terms of their effects on brain development, it has been determined that nutrition has a critical role at the intersection of biological and nutritional factors involved in the regulation of brain development. Let's examine the effects of nutrition on personality development starting from the prenatal period when the brain development is most intense.

a) THE EFFECTS OF MATERNAL NUTRITION

Since a child will be fed through the nutrient content of the blood of the mother from the moment it falls into the mother's womb, her nutrition that will affect the contents of the blood is vital. It was observed in a study conducted on monkeys that male offspring which received low iron during pregnancy showed behavioral changes with fewer natural daily activities than the control group (Golub et al. 2007).

Studies in rats and mice have determined that insufficient or excessive iron intake during pregnancy leads to some lasting behavioral changes in offspring (Fredriksson et al. 1999; de Deungria et al. 2000; Kwik-Urbe et al. 2000). These changes have been reported to be independent from the levels of iron and iron supplementation in their later lives. Furthermore, it has been shown that the lack of prenatal zinc increases the aggressiveness in the postnatal period (Halas et al. 1977).

It was revealed in the studies performed on humans that when pregnant women received iron supplementation during

pregnancy (20 mg/day), according to parents' reports, caused abnormal behavior in 4-year-old children (Zhou et al. 2006) but did not cause such an impact in the 6-8 age group (Parsons et al. 2008).

In addition, the children between the ages of 1-4, whose mothers with eating disorders such as anorexia or bulimia nervosa, were followed. While the weight and height of these children were slower than those of the healthy mothers, there was no difference between the childhood temperament (Waugh and Bulik 1999).

Neugebauer et al. evaluated the children, whose mothers who were not fed enough during pregnancy, in terms of antisocial personality disorder (ASPD) (Neugebauer et al. 1999). Between October 1944 and May 1945, pregnant women have been exposed to a moderate nutritional deficiencies as a result of blocking the entry of food by Germany to the Netherlands. The boys born by these mothers were assessed for military duty when they were 18 years old.

It was determined that the risk of ASPD was 2.5 times higher in the offspring whose mothers exposed to the lack of nutrients in the first three / six months of pregnancy, and the risk of ASPD did not increase in the last three months of exposure to moderate nutritional deficiency. In addition, it was indicated in the same study that men had the diagnosis of schizoid at the age of 18 (Hoek et al. 1996) and were hospitalized with the diagnosis of schizophrenia in adulthood (Susser et al. 1996).

Vitamin supplement of the pregnant women led to positive results. For example, it was observed that when mother received riboflavin, niacin and vitamin B-6, it was associated with alertness in children during newborn period (Rahmanifar et al. 1993). It was determined that new-born children whose mothers breast milk contained high vitamin B-6 were more responsive to aversive stimuli than others, and they were calmed more easily and caused less disturbance (McCullough et al. 1990).

b) THE EFFECTS OF NUTRITION IN THE POSTNATAL PERIOD

Malnutrition in the early childhood is very important in terms of cognitive development and behavior problems.

In a study investigating the relationship between malnutrition and externalized behavior problems in Africa, three-year-old 353 malnourished children and 1206 adequately nourished at the age of 8, 11 and 17 were followed up and they were evaluated in terms of antisocial behaviors at the age of 8, 11 and 17 (Liu et al. 2004).

It was observed that the children with nutritional deficiencies were more aggressive or hyperactive at the age of 8, they had problems of self-expression at the age of 11, and they had behavioral disorders and excessive motor activity at the age of 17. With these findings, the authors have concluded

that nutritional deficiencies increases the susceptibility to the neuro-behavioral problems and this makes the children and adolescents susceptible to the formation of persistent behavior problems. Severe vitamin B12 deficiency in infants leads to many neurological findings such as nervousness, dystrophy, apathy, loss of appetite, as well as retardation, and these findings can easily be eliminated with vitamin supplementation (Dror and Allen 2008).

In a study investigating the effects of malnutrition on temperament, the temperaments of 6-24-month-old 212 malnourished infants and 108 well-nourished children living in Bangladesh were assessed (Baker-Henningham et al. 2009). As a result it was observed in malnourished children that they were less sociable, less attentive, more anxious (more fearful), and had more negative emotionality. The researchers have stated that these temperament characteristics of the children may be a risk factor for behavioral and mental health problems in their advanced childhood period.

In a review carried out in Russia, Guatemala and Uganda on the effects of nutritional deficiencies on personality, (Brozek 1990) the following results were given. As a result of malnutrition during the famine years of 1918-1921 in Russia, profound changes in personality such as indifference in children and adults, mind being constantly busy with food, difficulty in remembering, decreased in physical and mental productivity, serious negligence in the traditional standards of behavior were observed. Endemic malnutrition was examined in Guatemala for 6-8 years.

Some of those with malnutrition received nutritional food supplements many years later. It was determined that the children with the history of good nutrition participated in group activities more, they were happier, less tense, they could express themselves better, behave more independently and control sudden behaviors better. Sixty clinically undernourished in the early infancy and 20 well-nourished infants were observed in their youth in Uganda. It was established that the undernourished were resting during the day, and they were more obedient.

In a study conducted on rats, it was shown that aggressive behavior increased in the early postnatal (1-40 days) with the occurrence of protein deficiency, and behaviors normalized with the administration of pyridoxine (Tikal et al. 1976).

As a result, it can be said that it is essential to remove nutritional disorders in the early childhood in terms of reducing behavioral problems that may occur in the future periods.

Energy

The amount of energy consumed could have effects on behaviors. It was observed in a survey conducted on children in Kenya that high energy intake was associated with more positive social and emotional behaviors and higher level of

activity (Espinosa et al. 1992). In other studies conducted in Kenya and Egypt it was found that high energy and protein intake in toddlers was primarily associated with higher level of mental performance and symbolic play (Jossey et al. 1989; Wachs, 1993). In another study conducted in Kenya it was found that nutrition with animal protein in the 18-30 month period was determinant in the cognitive functions at five years (Sigman et al. 1991).

A study on monkeys suggested that the amount of energy taken affected the activity of the puppy. The relation between the behavior of the infants and the energy of the milk sucked from their mothers was examined in this study. Milk power, the amount of milk energy (kcal/g) and milk productivity (g) were determined. In conclusion, it was observed that the offspring that took high milk energy showed higher activity, in addition, they were more confident in stressful environments (Hinde and Capitanio 2010).

Protein Deficiency

Protein is an essential source of amino acids for the fetus showing rapid growth. Protein deficiency has been associated with antisocial behavior problems. Liu et al. reported that lack of protein at the age of 3 caused behavioral disorders when they reached 8, 11 and 17 years old (Liu et al. 2004). PET (positron emission tomography) images of the violent offenders revealed that there were deficits in the prefrontal cortex and corpus callosum regions of the brain (Volkow et al. 1995; Raine et al. 1997).

To confirm this, however, negative responses in the corpus callosum regions of the brain and low DNA concentration were observed in the forebrain of the offspring of rats fed with a low protein diet during pregnancy (Bennis-Taleb et al. 1999). As a result, researchers reported that protein deficiency could contribute to the formation of disorders in the brains of violent criminals.

The Effect of Breast Milk

It was observed between the formula-fed and breast-fed 4-month-old infants that, breast-fed infants consumed the same amount of nutrients more slowly. However, no difference in terms of alert, pleasant, drowsy, restless residence time, crying time, activity and temperament was observed (Wells and Davis, 1995). In a study conducted in the United States (among low-income blacks) the babies who were initiated additional nutrients before 4 months, were followed until they were 18 months old and the relation between early start of complementary foods and being fussy was researched. According to the feelings of mothers, there is a potential relationship between early start of supplementary foods and being fussy (Wasser et al. 2011).

A study conducted in England investigated the effects of breast-feeding on infant temperament including 316 three-

month-old infants (Lauzon-Guillain et al. 2012). It was observed that these babies were more tiring (more crying, less smiling, being soothed later) than bottle-fed ones have been shown.

c) THE EFFECTS OF FEEDING IN ADULT PERIOD

Vitamins, Minerals and Fatty Acids

In addition to the effects of malnutrition during maternal or infancy period on behaviors, the lack of some nutrients adversely affects the behaviors in adulthood.

In a study of the effects of -intermediate level iron-zinc deficiency on the behaviors of adolescent monkeys were studied. Low activity in behaviors, low participation to the behavioral tests and reduced response were observed. These changes were reversed or prevented to a certain extent with the addition of zinc and iron (Golub et al. 2000).

In a study conducted in mice, it was found that there was a significant relationship between anxiety-related behavior with blood magnesium levels and a possible relationship between magnesium status and sentimentality was emphasized (Laarakker et al. 2011).

In an observational study carried out on 231 young prisoners in the UK, it was investigated whether taking physiologically adequate vitamins, minerals and essential fatty acids would give rise to a reduction in antisocial behavior (Gesch et al. 2002). Disciplinary offenses before and after support treatment were compared, and it was observed that antisocial behaviors including violence decreased.

Some studies have established that there are relations between over-aggressive behavior and lack of vitamins and minerals (Werbach 1995; Breakey, 1997). Moreover, a study claims that almost one-third of young population who commits a crime (mostly male) have iron deficiency (Rutter et al. 1998). However, these results are conflicting and controversial (Rutter et al. 1998). In the PET images of the violent offenders, abnormal working sighted amygdala (a brain region) (Raine et al. 1998; Davidson et al. 2000) was stimulated by the heavily zinc-containing neurons (Christensen and Frederickson 1998).

The zinc and iron levels in the blood of men with a history of aggressive behavior were found to be lower than those who displayed no aggressive behavior (Walsh et al. 1997).

B12 vitamin and folic acid deficiency have negative impact on the behaviors. It was reported in a study conducted at Izzet Baysal University in Bolu that a case of a young patient with vitamin B12 deficiency had the psychotic symptoms such as irritability, regressive behavior, apathy, crying and truancy and all these symptoms disappeared following the treatment with B12 (Tufan et al. 2012).

A number of studies have reported that severe folate deficiency may increase the loss of cognitive function in the elderly (Fine and Soria 1991; Metz et al. 1996; Quinn and Basu 1996). Lack of essential compounds, such as folic acid and vitamin B12 and is considered to be a risk factor for cognitive function impairment, neurodegenerative diseases associated with depression and Alzheimer's disease (Gottfries et al. 2001). In fact, Alzheimer's patients with low levels of vitamin B12 have more behavioral and psychological symptoms of dementia when compared to those with normal vitamin B12 levels (Meins et al. 2000). Therefore, it is considered that vitamin B12 plays a role in the pathogenesis of the behavioral changes in Alzheimer's patients.

The Effects of Certain Nutrients

In a study known as the Minnesota study conducted on 25-year-old healthy men, a diet was planned as 12-week controlled period, 24-week starvation period and 12-week rehabilitation period. 50 g protein and 30 g fat was provided so that it could be 1570 Cal during starvation period. At the end of 24 weeks, body weight decreased by 25%. Psychoneurotic type of personality changes were observed in the period of starvation. However, when they were nutritionally rehabilitated and returned to their normal weights, these changes returned to normal (Keys et al. 1950).

In a study conducted to investigate the effects of blood glucose level on aggression, it was seen that the ones who drank sugar sweetened lemonade displayed less aggressive behavior than those who drank sugar-free (sweetened) lemonade (DeWall et al. 2011). Researchers have explained it as follows: "The brain uses glucose as an energy source. While self-control, more amount of energy (glucose) is required. When there is enough glucose in the blood to be used, it makes it easy to control himself. A spoonful of sweet will help you to defeat anger."

Garrido et al. carried out a study to investigate the effects of cherries on the state of feelings of humans. They prepared a 125 ml cherry drink using approximately 141 g cherries (dried, ground and diluted cherry + maltodextrin + citric acid) and it was consumed for a period of five days, including lunch and dinner (Garrido et al. 2012). Its effects on family relationships, social relationships, mood and well-being were compared between young, middle-aged and elderly individuals and it was observed that it had positive effects on mood and well-being with a decrease in anxiety at middle and advanced ages, and family relationships improved in youth. Cherry is one of the food supply of tryptophan, serotonin and melatonin. It is synthesized from serotonin tryptophan known as the hormone of happiness and affects mood positively. Tryptophan is an essential amino acid and should be taken with food.

The researchers attributed the positive impact of cherry on social relations and mood to the tryptophan and serotonin found in it. They suggested that serotonin and tryptophan which is a source of serotonin could demonstrate this effect by increasing the level of serotonin in the blood.

Moderate consumption of coffee - behavior relationship was summarized in a study in which the effects of coffee on mood, mental performance, and sleep were compiled as follows (Smith 2002); 1. Coffee increases alertness and reduces fatigue, this is especially important when there is little stimulation, such as night work, 2. It improves work performance in the tasks requiring attention and the simple tasks requiring to be answered continuously, and this effect is most clearly observed in cases when wakefulness decreases, 3. It is more difficult to assess the impact on more complex jobs, and besides coffee consumption, the individual's personality and other factors that increase alertness, such as the time of day should be taken into account, 4. Contrary to caffeine consumption, giving up coffee is much less effective on the performance, 5. Having caffeine seems to be helpful. Higher amount effects mental functions more positively, 6. Generally individuals are good at controlling the amount of caffeine they will consume in order to maintain positive effects at a high level. Basing on these findings it can be concluded that the amount of caffeine consumed by the majority of people has positive effects on behaviors. Excessive consumption may cause problems especially in individuals with delicate physique and in some psychiatric patients.

d) RELATIONSHIP BETWEEN TEMPERAMENT AND EATING BEHAVIOR

In some studies it has been evaluated that temperament may have effects on eating habits. In these studies, poor self-esteem (Wooley et al. 1979), perceived stress (Rodin et al. 1989), and body image disorder (Thompson and Tantleff-Dunn, 1998) were associated with the development of obesity. However, some studies have indicated that very few personality features are the determining factor for obese patients (Leon and Roth 1977). Wells et al. have investigated the role of maternity-related infant temperament in determining the future composition of the body and behaviors (activity patterns). Three-month-old, and the children aged 2-3 and 5 years old were followed-up.

It has been stated that the temperament of babies can be determinant on their later behaviors and fat percentages of their bodies. It has been observed that easily calmed infants have thinner (oil-free) complexion during childhood and spend a more active childhood. It has also been determined that the difficulties experienced in infancy or childhood are related to the composition of the diet (Wells et al. 1997).

Haycraft et al. have investigated the relationship between eating behaviors and temperaments of 3-8 year-old 241 children (Haycraft et al. 2011). Those with emotional temperament showed more food avoidant eating behaviours. Shyness, sociability, and being active characteristics have no association with children's eating behavior. It has been observed that the children with a high BMI have exhibited more tendency to eating behavior but BMI is not related to their temperament.

Martin et al. followed 1228 children from infancy to the age of 12-13 and they investigated the relationship between temperament with eating problems. As a result, they related the temperament of childhood, especially of the girls, (High Negative Emotionality and low persistence to the development of interest in food in later period (Martin et al. 2000). Wonderlich et al. associated the behaviors related to temperament such as acting impulsively reactive (reactivity / impulsive act- impulsivity) with the disordered eating attitudes and behaviors in their study on adolescents (Wonderlich et al. 2004).

In another study in which girls between the ages of 8-12 were followed for 7 years it was reported that although having activity temperament was associated with less body fattening and nonresting high-energy expenditure (NREE), no evidence that was determinant (predictive) of body fattening was detected (Anderson et al. 2005). The temperaments of children can affect not only their feedings but also their mothers' feeding behaviours of their children.

Vollrath et al. carried out a study to find out this relationship (Vollrath et al. 2011) and included 40 266 mothers and children, and they evaluated children when they were 18 months old. It was observed as a result that the children with distress-prone temperament, particularly internalizing, were given more sweet food and sweet drinks. They concluded that mothers gave more sweet food and beverages to cope with the children's behaviors. They also emphasized that these children should be followed in terms of obesity in the future.

When assessed collectively, the above data suggests that temperament might be related to problems of eating in later periods.

e) PSYCHIATRIC DISORDERS AND NUTRITION

Nutritional deficiencies is associated with schizophrenia, schizoid personality disorders (Hoek et al. 1996; Dalman et al. 1999; Tsuang 2000) and antisocial behaviors (Fishbein and Pease, 1994). It has been observed in a double-blind, placebo-controlled, randomized study especially on the prisoners by giving nutritional supports that antisocial and violent behaviors decreased with nutritional support (Gesche et al. 2002).

Fish contain nutrients have been reported to be useful for brain functions, schizophrenia (Post 1999; Warner et al. 1999; Mahadik et al. 2001) and externalized behavior disorders as they contain omega-3 fatty acids (Arnold et al. 1994; Corrigan et al. 1994; Mellor et al. 1995; Stevens et al. 1996) have been reported to show beneficial effects. Though not evident, there is some evidence that nutritional deficiencies exposed in the mother's womb may increase the risk of schizophrenia later in life (Susser et al. 2008). In addition, it has been stated that low (<2.5 kg), or high (> 4.0 kg) birth weight (Gunnell et al. 2003) and being thin in childhood (Wahlbeck et al. 2001) are risk factors for schizophrenia in adult life.

Venables and Rainer followed 1795 children from birth and investigated the relationship between malnutrition, intelligence level, and being predisposed to schizophrenia (showing light schizophrenic behaviors) (Venables and Raine, 2012). The children were evaluated in terms of their malnutrition status regarded as anemia and stunting when they were 3 years old, intelligence level (IQ) at the age of 11, and schizophrenic character traits at the age of 23. They found that nutritional deficiency (anemia and stunting) at the age of 3 was associated with lower IQ at age of 11. Low IQ performance at the age of 11 was associated with the interpersonal and impaired schizophrenic personality traits at the age of 23. According to the survey results: low IQ mediates both malnutrition at the age of 3 and the interpersonal and impaired schizophrenic personality development at the age of 23.

It has been reported that many neuropsychiatric diseases such as dementia, schizophrenia-like syndromes, insomnia, irritability, forgetfulness, endogenous depression, organic psychosis can be associated with folic acid deficiency (Kelly, 1998). Coronary heart diseases are often accompanied by some mental problems. Depression is a risk factor for the development of CHD and poor prognosis of CHD (Frasure-Smith and Lesperance, 2006).

The studies that investigated the depression and n-3 PUFA association on coronary patients showed that low plasma or membrane n-3 PUFA (especially DHA) levels were associated with depression (Frasure-Smith et al. 2004; Parker et al. 2006; Schins et al. 2007; Amin et al. 2008; Ali et al. 2009). However, such a clear relation was not reported in the cases without CHD (Appleton et al. 2008; Van de Rest et al. 2008).

In a study conducted in rats, the long-term adverse effects of consuming too much sugar or sweeteners during adolescence were investigated (Vendruscolo et al. 2010). It was stated that the consumption of too much sugar in rats triggered specific chronic depression during the reward processing in the development period, and it was reported that

it may increase susceptibility to psychiatric disorders associated with rewarding.

Genetic and environmental factors play a role in the etiology of psychiatric disorders such as schizophrenia and depression. When the above data is evaluated, it is possible to say that nutrition and / or certain vitamin deficiencies may play a role in the development of these diseases.

f) FOOD ADDITIVES AND BEHAVIORS

Food additives are the substances added to the products in order to improve the properties such as taste, smell, flavor, appearance, nutritional value and shelf life of foods. These substances are likely to be exposed to in every period of life. The relation between food additives and behavior is evaluated rather considering the effects of additives increasing hyperactivity. This disease whose full name: "Attention Deficit Disorder" or "Attention Deficit Hyperactivity Disorder (ADHD)" is one of the most common psychiatric disorders of childhood and affects approximately 3-10% of the children during the school terms and is more frequent in boys.

ADHD often begins to reveal itself with findings such as inattentiveness, hyperactivity, impulsivity, intolerance against obstacles, ill humour, aggression, adjustment difficulties, emotional lability, impulsive behavior after 3 years old. In the first years of school, findings such as incapability of learning, perceptual problems and school failure stands out (Mattes and Gittelman 1981; Boris and Mandel 1994; Doğruyol 2006). The causes of ADHD are still largely unknown, but according to the popular view; genetic and environmental factors play a role in the formation of the disease (Aguir et al. 2010).

The claim that additives cause hyperactivity and some neuropsychological disorders in sensitive children was first put forward by Feingold in 1976 (Feingold 1976; Feingold 1977). In the following years it was tried to find relationship between ADHD and additives, and conflicting reports on this subject were obtained in many studies (Conners 1976; Harley et al. 1978; Harley and Matthews, 1978; Conners 1980; Eigenmann and Haenggeli 2004).

In a study by Conners et al. in 1976 including 15 hyperactive boys, it was observed that the hyperactive symptoms decreased significantly in the children, who were fed with the diet proposed by Feingold free from synthetic colorings, flavorings and salicylates, according to their teachers. Based on the evaluation of the parents, this study has concluded that there is no change in the symptoms (Conners et al. 1976). Conners gave Feingold diet free from food dyes to 16 hyperactive children ranging from ages 4-11 in another study, and according to the evaluation of parents hyperactive symptoms decreased in 57% of children and according to the teachers 34% decrease was observed. It was

found only in 3 children that visual-motor performance decreased 1 hour after the diet with food coloring ingestion (Conners, 1980).

In 1978, Harley et al. reported contrary to Feingold hypothesis that there was no effect of food additives on behavior, however, they could not support this hypothesis in their later works (Harley and Matthews, 1978; Harley et al. 1978).

Spring and his colleagues administered additive-free diet to 6 hyperactive children first in order to test hypothesis of Feingold and all parents stated that this diet was effective. However, increase in hyperactive symptoms were observed only one child with the diet with additives. The authors argued that there was insufficient data to support the hypothesis of Feingold (Spring et al. 1981).

The most extensive clinical research on behavioral and cognitive effects of food additives was conducted by Ward in 1997. It has been shown according to the survey evaluation results of this study that there is a relation between behavioral disorders and food additives in 60% out of 486 hyperactive children whose ages ranging from 7-13. In the control group, this ratio was found to be 12 % (Ward, 1997).

Mattes and Gittelman gave Feingold's diet free from additives, a diet containing food dyes and a diet containing food dyes but its image and smell did not reveal that it contained food dyes (placebo) to 11 hyperactive children for a period of one week respectively (1981). When the symptom scores were assessed with the teachers, parents and psychiatrists data and psychological tests, it was observed that Feingold's diet did not cause any significant changes in symptoms. Mattes reviewed all the reports investigating the relationship between food additives and hyperactivity between the years 1976 -1983, and claimed that there was no significant relationship between Feingold's diet and decrease in the symptoms of hyperactivity (Mattes, 1983).

Boris and Mandel (1994) determined significant regression in ADHD symptoms with Feingold's diet free from additives in 19 out of 26 children conforming with ADHD diagnostic criteria. It has been reported that the children with ADHD accompanied by atopy responded better to the treatment-free diet. In a placebo-controlled double-blind study carried out by Bateman et al. (2004), the children were given chemical colorants and preservatives-free food for a week initially, and then 20 mg colorant (sunset yellow FCF, tartrazine, carmoisine, ponceau 4R), 45 mg preservative (sodium benzoate), and placebo were given per day for three weeks to the randomly selected groups separately. At the end of the study it was pointed out that there was significant decrease in the hyperactive behaviors with the withdrawal of chemical colorants and preservatives from the diet, and there was significant increase and with the addition of these

substances to the diet, and this changing was independent of the underlying disease.

McCann et al. (2007) added two separate mixture (Mixture A: Tartrazine, Ponceau 4R, Sunset Yellow FCF and Sodium benzoate; mixture B: Quinoline yellow, Sunset yellow FCF, Allura Red, Carmoisine and Sodium benzoate) containing different proportions of additives to the diets of total 267 children in the age group 3 years and 8-9 years as double-blind and randomized. The researchers in this study, evaluated the effects of synthetic colourants and preservatives on behavioral models basing on the teacher observation, parental observation and classroom observation. While significant influence was observed in the behavior models of 3-year-old children given mixture A when compared with placebo, no significant changes in those given mixture B. However, it was determined that both mixtures had negative effects on behavior models in the 8-year-old patient group. This interaction has been reported to vary depending on dose and age (McCann et al. 2007). Pelsser et al. investigated the effects of additive-free diet on the disease symptoms in 27 children patients diagnosed with ADHD, and the results were evaluated by parents and teachers (2009). According to the parents judgment; a decrease in disease symptoms was observed in 73% of of the children , and according to the teachers; a decrease in disease symptoms was observed in 70% of the children. In the control group, these percentages were 12% and 0% respectively (Pelsser et al. 2009).

The Additive-Free Foods

It may be helpful to examine the studies investigating positive effects of food additive-free foods in terms of understanding the negative effects of food additives.

One of these studies is a research study of organic foods. In a study Fuchs et al. carried out and known as "monastery work", 17 nuns were fed with organic foods for a month and physiological and psychological effects were evaluated. Decrease in blood pressure, strengthening in the immune system, physical fitness and an increase in mental clarity were observed. In addition, it was stated that the nuns fed with organic foods suffered from fewer headaches and could cope better with stress (Fuchs et al. 2005).

It was investigated whether nutrition in childhood is associated with the tendency to violence in adulthood in another study conducted in England (Moore et al. 2009). To do this, people who ate foods like chocolate, cake, candy, etc. every day for 10 years in their childhood were assessed when they became 34 years old and it was determined that they were sentenced from violence significantly more than those who had not eaten them. While discussing the possible causes of this, authors cited that food additives in foods consumed might increase aggression, continuous rewarding

children might have some of negative effects psychologically, and might result from the bad attitudes of the parents.

The effects of environmental enrichment program, in which foods without additives are consumed, on light schizophrenic personality and antisocial behaviors were investigated in a study conducted on an island nation in the Indian Ocean, Mauritius (Raine et al. 2003). 83 children were randomly selected among the 3-5-year-old children living in the country for the environmental enrichment program, and 355 children were evaluated as the control group. Enrichment program started when they were 3 years old and lasted for 2 years. In this process, special nutrition, education and physical exercise programs were performed. Milk, fruit juice, given a meal of fish or chicken and salad were given as nourishment. They were given speech, coordination, cognition, and memory skills training as education, gymnastics and street plays, etc. activities were made as physical exercise. When the kids became 17 and 23 years old, they were evaluated in terms of mild schizophrenic personality and antisocial behaviors. As a result, environmental enrichment in the early period had detractive effects on slightly schizophrenic personality and antisocial behavior, and it was concluded that this positive effect was most obvious in children with malnutrition.

The effects of food additives on behavior can be summarized as follows: The only known adverse effect of additives on behaviors is ADHD. However, although there are studies supporting that synthetic food dyes have increased disease symptoms, there are also studies showing that they have no negative effects. Further well-planned studies are required to clarify the results.

OVERALL EVALUATION

Behaviors are outward reflection of personality and is shaped by genetic and environmental factors. Nutrients, one of the environmental factors and consumed with foods, are indispensable elements for both prenatal and postnatal life to lead a healthy life at every stage of life and to demonstrate healthy behaviors. In addition, the social environment and education are at least as important as nutrition. Nutrition is essential to create a healthy development basis. Social environment and education are essential to form and improve healthy infrastructure. For the healthy development of brain which is a main organ and completes its development substantially in the early childhood and determines our behaviors requires sufficient vitamins, minerals, amino acids and fatty acids in order to thrive healthily. Some vitamin and mineral deficiencies in childhood and adulthood during which brain completes its development can lead to negative behaviors. Natural food can affect our behaviors through nutrients and active molecules they contain. Lack of some

nutrients can contribute to the formation of psychiatric diseases. Food additives should be regarded as a risk factors increasing hyperactivity especially in patients with ADHD.

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