

# Whom to Blame for Brain Health and Appetite Slump in Toddlers? A Narrative Review

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## Abstract

Food preference in children depends on the interplay between genetic and environmental factors. Exposure to flavors during prenatal and postnatal period through amniotic fluid, breast milk, and weaning foods have been identified as possible influences on food preference and acceptance in children. Therefore, maternal nutrition has a strong influence on the child's food preference early in life. **Aim:** The authors carried out a narrative review to understand the contribution of maternal nutrition on the food preferences in children in later life. **Methods:** The authors retrieved the articles from SCOPUS, Medline, Science Direct, CINAHL, EBSCO, and PubMed central databases. The key words including food preferences, food choice, and acceptance of food, pregnant women, toddlers, and food culture were used to identify the appropriate articles. The authors included in the review, full-text articles, published in English language between 1995 and 2018. In total, six articles, which met the inclusion criteria, were included in the final review. **Results:** The results revealed that there is a very strong connection between the exposure to flavors during prenatal and postnatal period and food preference and acceptance in children in later life. The olfactory and gustatory exposures to flavors during prenatal period through maternal diet, and during postnatal period through breast milk and weaning foods determines the food preferences in childhood. **Conclusion:** We conclude that maternal nutrition has a strong influence on the child's food preference early in the life, therefore effective strategies should be designed to increase healthy feeding choices during the prenatal and postnatal periods.

**Keywords:** Appetite slump, brain health, food preference, maternal feeding habits, weaning foods

## INTRODUCTION

Food is a great resource in maintaining health, thwarting diseases, and prolonging the lifespan, and it is imperative to study their impact based on the context of ingestion.<sup>[1]</sup> Brain growth and development start right at conception. This is the time when the male and female gametes meet and form a single cell to begin human life. This means that brain cell growth of a baby starts very early in pregnancy. This awareness is critical because, right before conception a woman needs to have a well-balanced diet with all the essential nutrients to prepare her body for conception.<sup>[2]</sup> This nutritional preparation is important because mother's body undergoes several changes during pregnancy to enable her to successfully nurture and grow the "seed in her womb" to a perfect healthy human being.<sup>[3]</sup>

Interestingly, novel research shows that at this time we can start shaping baby's food habits, by indirectly introducing the baby to a variety of food types through what the mother eats.<sup>[4]</sup> This early priming of baby's food habits by expecting mother's good eating habits is a welcome news. This is important because nowadays, many parents struggle with feeding their children, not because of lack of food but because of their children's disinterest in food.<sup>[5]</sup> The result

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of this increasingly common observation is that many children are undernourished and often sick right from early childhood.<sup>[6]</sup> This is an avoidable consequence if unborn babies and toddlers are exposed to different food choices. This is particularly possible because of the dietary abundance and availability of a wide range of food choices. Indeed, today infants are born into a wide variety of cultures and cuisines, which they can adapt to upon exposure.<sup>[7]</sup>

The argument that the baby's taste buds can be trained early is supported by the fact that taste buds develop during the 13th week of pregnancy. Furthermore, a fetus begins swallowing amniotic fluid at around the same time and develops a powerful sense of smell.<sup>[8]</sup> This phenomenon has been documented in rodents and rabbits as well.<sup>[9,10]</sup> This research finding supports the argument that pregnancy is the right time to start developing a healthy food culture in the unborn child. In essence, the food a mother eats at this time does not only nourish her body, but it also nourishes the baby in her womb in addition to grooming her unborn baby's appetite and food preference in later life.

The mechanism for appetite priming is since every food item has its unique flavor.<sup>[11]</sup> So when a mother eats a particular food, her amniotic fluid is flavored by that food. As the baby swallows the fluid, it gets to know the different flavors of the foods the mom eats. These different "memories of these flavors" get firmly embedded in the baby's brain even before birth and that will affect the child's preference for similar foods later in life.<sup>[12]</sup> This means that early exposure of a fetus to different food flavors before birth enables them to accept a variety of foods later in life, thereby improving their brain and physical health, thereby underscoring the need for the mother to eat as diversely as possible during pregnancy.<sup>[13]</sup>

Hence every pregnant woman needs to make healthy food choices at each mealtime by including a wide variety of nutrients. This can later on prevent her children from developing various nutrition related disease conditions. It also follows that it is within every woman's reach to nurture and develop children with good brain health by introducing them early to good food habits intranatally and postnatally. This practice would reduce hours of forced feeding and unpleasant doctor's visits. This paper presents the contribution of mother's food intake during pregnancy on the food preferences of toddlers in later life.

## MATERIALS AND METHODS

A search strategy was formulated by the authors to individually search literature to retrieve articles from databases about studies focusing on food consumption during pregnancy and toddler's food choice. The articles were searched and retrieved from databases including SCOPUS, CINAHL, and PUBMED. To conduct the literature search we employed the following MeSH terms: a. (food preferences), b. (food choice), c. (acceptance of

food), d. (pregnant women), e. (toddlers), and f. (food culture). A secondary search involved scanning the reference lists of articles identified from the primary search. Both search strategies were limited to articles published in English language. Six articles which met the inclusion criteria were selected and were studied in-depth by the authors and used to create a data table [Table 1].

## RESULTS

The results of the six studies reveal that there is a very strong connection between the food consumed by the pregnant women and the odor of the amniotic fluid. The findings of a study done by Mannella and colleagues in the year 1995 showed that there was alteration in the odor of amniotic fluid according to the food intake of pregnant women. The study was done among 10 women who were either given placebo or garlic capsules. Four out of five women who had garlic capsules had a strong odor of garlic in their amniotic fluid, when compared with the women who had received placebo capsules.<sup>[14]</sup>

Similarly, a follow up study was later conducted by Mannella and colleagues in 2001 to test whether a flavor in amniotic fluid or breast milk modifies the infants' acceptance and enjoyment of similarly flavored foods at weaning or not. The result showed that the infants who had exposure to the flavor of carrots in either amniotic fluid or breast milk exhibited fewer negative facial expressions while being fed carrot-flavored cereal compared with the plain cereal.<sup>[15]</sup>

Another important study is the Dutch population-based cohort study by de Barse, *et al.* (2017) examined the associations between infant feeding and child fussy eating in 4779 participants. The study which assessed breastfeeding initiation and continuation and timing of complementary feeding showed that children who were breastfed for less than 2 months had a 0.70 points higher food fussiness sum-score (95% CI: 0.27; 1.12) than children breastfed for 6 months or longer. An earlier introduction of vegetables was associated with less fussy eating behavior (*P*-trend: 0.005). Similarly, children who were introduced to vegetables between 4 and 5 months had a 0.60-point lower food fussiness score (95% CI: 1.06; -0.15) than children introduced to vegetables after 6 months.<sup>[16]</sup> Many studies have earlier proved that the food the pregnant women consume has its flavor in breast milk and in amniotic fluid. Even though this study is related to the flavor of breast milk and toddlers' eating habits, it too shows a link between the flavor of amniotic fluid and food consumed by pregnant women.<sup>[13,14]</sup>

A cross-sectional survey to ascertain the relative contribution of food neophobia, the characteristic fear of novel foods, and taste sensitivity among mothers and children found that parental and child fruit and vegetable consumption during pregnancy is positively associated at (*P* < 0.001).<sup>[17]</sup> Another cross-sectional study by Hendrick *et al.*<sup>[18]</sup> among 2515

**Table 1: Summary of the reviewed articles**

Author, year, and country of study	Study purpose	Study design	Sample size	Data collection	Key findings
Mennella JA, <i>et al.</i> , 1995USA	Garlic Ingestion by pregnant women alters the odor of amniotic fluid	Experimental research design	10 pregnant women	Amniotic fluid from pregnant women undergoing routine amniocentesis procedure. Approximately 45 minutes prior to the procedure, five of the pregnant women ingested placebo capsules, whereas the remaining five ingested capsules containing the essential oil of garlic. And were then evaluated by a sensory panel of adults.	The odor of the amniotic fluid obtained from four of the five women who had ingested the garlic capsules was judged to be stronger or more like garlic than the paired samples collected from the women consuming placebo capsules.
Mennella JA, <i>et al.</i> , 2001USA	Prenatal and postnatal flavor learning by human infants	Experimental research design	46 pregnant mothers of last trimester of pregnancy and who planned to breastfeed their infants	Pregnant women who planned on breastfeeding their infants were randomly assigned to one of three groups. The women consumed either 300 mL of carrot juice or water for 4 days per week for 3 consecutive weeks during the last trimester of pregnancy and then again during the first 2 months of lactation.	The results demonstrated that the infants who had exposure to the flavor of carrots in either amniotic fluid or breast milk behaved differently in response to that flavor. Specifically, previously exposed infants exhibited fewer negative facial expressions while feeding the carrot-flavored cereal and infants who were exposed to carrots prenatally were perceived by their mothers as enjoying the carrot-flavored cereal more compared with the plain cereal.
de Barse LM, <i>et al.</i> , 2017The Netherlands	Infant feeding and child fussy eating: the Generation R Study	Prospective cohort	Parents of 7295 children	The food fussiness scale of the Children's Eating Behaviour Questionnaire (CEBQ) was used to assess fussy eating	Sensitivity analyses on exclusive breastfeeding in the first 4 months of life showed that children who were exclusively breastfed for at least 4 months ( $N = 1072$ ) did not differ significantly in their food fussiness scores from children who were partially breastfed at 4 months ( $N = 1869$ , $B = 0.33$ , 95% CI: $-0.04$ ; $0.70$ ) or never breastfed ( $N = 234$ , $B = -0.32$ , 95% CI: $-1.01$ ; $0.38$ ; data not shown in tables).
Coulthard H & Blissett J., 2009UK	Fruit and vegetable consumption in children and their mothers. Moderating effects of child sensory sensitivity	A cross-sectional study	Two hundred questionnaire packs	Sensory processing, parental control, child food neophobia and fruit and vegetable (FV) consumption of both mothers and children were measured.	Parental and child FV consumption in the sample were positively associated ( $p < 0.001$ ). Moderated regression analyses showed that taste/smell sensitivity, but not food neophobia or tactile sensitivity, moderated the relationship between maternal and child FV consumption
Hendricks K, <i>et al.</i> , 2006USA	Maternal and child characteristics associated with infant and toddler feeding practices	Cross-sectional study	US infants and toddlers aged 4 to 24 months 2002	A national random sample of mothers ( $n = 2515$ ) whose infants and toddlers aged 4 to 24 months made up the Feeding Infants and Toddlers Study cohort.	Having a college education was the maternal characteristic associated with the largest number of positive child feeding behaviors (OR 2.8, 3.2, and 3.9, respectively). College-educated mothers were significantly more likely to comply with the American Academy of Paediatrics juice and complementary feeding recommendations (OR 1.4 and 2.0).
Santos LS, <i>et al.</i> , 2018	Influence of mother nutrition during pregnancy and/or lactation on offspring food preference in experimental models	Experimental research design	Systematic review 11 articles reviewed	The identified studies were evaluated according to the criteria of inclusion: studies with rats or mice, which were exposed to some kind of diet during the intrauterine period of life and/or lactation. The articles were pre-selected and those who do not fit the established criteria were excluded from the review. For analysis of the studies, were summarized in a table.	The selected studies suggested that unbalanced nutrition in early life alters the food preference and neural components related to the consumption of fatty and sugary foods in offspring rodents.

mothers whose infants were in the age group of 4 to 24 months, showed that maternal education had an impact on infants and toddler food preferences. The study also concluded that decreased duration of breastfeeding was positively associated with preference of infants and toddlers to salty snack items. Furthermore, a systematic review to understand association between food preferences and maternal nutrition during pregnancy and lactation concluded that unbalanced nutrition in early life alters the food preference and neural components related to the consumption of fatty and sugary foods in offspring.<sup>[19]</sup>

## DISCUSSION

Food acceptance and eating pattern of an individual is based on the preference set during fetal life.<sup>[11]</sup> In addition, the food fragrances and flavors one was introduced to from fetal life in the womb equally affect the preferences of the newborn and the toddler. Prenatal and postnatal exposures to flavors through amniotic fluid and breast milk has influences on food acceptance since the like for flavor is the major determinant of food preference.<sup>[20]</sup> Research shows that fetuses swallow amniotic fluid from the week 13th of gestation once their gut develops and can equally taste the flavor of the food content and register the differences in their brain.<sup>[14]</sup> Mennella *et al.*<sup>[14]</sup> found that the children of women who drink carrot juice daily in the last few months of pregnancy and during the lactation had a stronger preference for carrot flavor later in life. Similar study by Mennella *et al.*,<sup>[14]</sup> with garlic also proved similar results. According to her, you can train foods through repeated exposure, and the younger it is easier to mould neural pathways of the unborn baby, further emphasizing the role of training.

Eating behavior of toddlers continues to be a major issue of concern causing parents' worry. This is partly because parent fear that their children's eating habits might interfere with their toddlers need for high energy requirements for their motor skills development. Parents have a high degree of control over the environments and experiences of their children. For instance, the usual preference by children for high-fat and sweet foods reported in many countries and the near universal dislike for vegetables suggests the existence of innate predispositions towards tastes.<sup>[21]</sup> The Feeding Infants and Toddlers Study (FITS) results showed that out of 3022 infants and toddlers, 18% to 33% consumed no distinct servings of vegetables on a typical day and only French fries was the most common choice of vegetable.<sup>[22]</sup> This means that parents were not trying enough to introduce their toddler to a wide variety of foods.

To support this widespread problem, a Canadian Community Health Survey found that seven out of 10 children aged 4 to 8 years failed to meet the minimum number of servings for vegetables and fruit in Canada's Food Guide to Healthy Eating.<sup>[22]</sup> This finding implies that prenatal mothers need

to eat a variety of flavored food items to help the babies accept a wide variety of foods later in their life.

Another problem associated with poor eating in toddlers is development of long-standing problems, which are often associated failure to thrive. This observation is more common in children who are neophobic, who fear trying out new food. In a study among 800 participants, Qazaryan and Karim<sup>[23]</sup> identified that majority of pre-schoolers (620, 77%) were described by their parents as poor or "picky" eaters. Further analysis of these groups showed there were significant impairments among "picky" eaters in the growth rates and BMI when compared to the "non-picky" eaters. The detrimental effect of the poor eating habit was also reflected in other domains such as fear of being in unfamiliar places (65% vs. 13.3%), fear of being lonely (14.6% vs. 12.1%), and low physical mobility (36.8% vs. 17.7%). In addition, the infants also experienced learning disability (16.2% vs. 7%), attention deficit (11.8% vs. 4.3%), communication delay (4.6% vs 3.3%), respectively among the "picky" and "non-picky" eaters. In a clinical study three quarters of children who had been "refusing to eat" early in the first year, when followed up to the age of 2 years, had persisting eating problems as well as poor weight gain. This clearly implies that a subgroup of problem eaters has long-standing problems associated with failure to thrive.<sup>[24]</sup>

Breastfeeding has a strong influence on the food preferences and satiety cues of young infants and toddlers.<sup>[25]</sup> Supporting literature prove that breastfeeding strongly influences early metabolic imprinting, which partially accounts for later differences in eating behaviors. However, the role of prenatal exposure of the fetus to amniotic fluid in setting food preferences among infants and toddlers is often neglected. This realization further underscores the importance of reviews such as this that articulate this observation.<sup>[26]</sup> The need to emphasize prenatal nutrition is supported by the observation that the nutritional environment to which an individual is exposed during the perinatal period plays a crucial role in determining his or her future metabolic health outcomes.<sup>[27]</sup> Studies in rodent models have demonstrated that excess maternal intake of high-fat and/or high-sugar "junk foods" during pregnancy and lactation can alter the development of the central reward pathway, particularly the opioid and dopamine systems, and program an increased preference for junk foods in the offspring.<sup>[28]</sup> Given the similarity between human and such species, it is very likely that such a relationship would hold true in human fetuses and toddlers in later life, thereby underscoring the need for proper dietary habit formation in early prenatal and postnatal period, as a proven strategy to improve toddler preferences.

In fact, several investigators have demonstrated a link between fetal interaction with the intrauterine environment and the acquisition of flavor and food preferences during weaning or later childhood.<sup>[29]</sup> These studies have identified three successive stages, which are crucial for modifying the



food preferences: early development, prenatal period, lactation, and early childhood at weaning. The exposure received during this phase results in modifications in the expression of flavor, food and drink preferences in later stages of life. The researchers have therefore concluded that since prenatal and postnatal exposures to different flavors determine the extent to which innate dispositions to tastes are expressed, effective strategies that increase children's healthy feeding patterns can be formulated.<sup>[30]</sup>

## CONCLUSION

The researchers conducted an extensive enquiry to establish the existence of a link between fetal exposures in the intra-uterine life and the eating pattern of child after birth. Therefore, it can be concluded that fetal exposure to food flavors during early development stage in the womb influences the expression of flavor, food, and drink preferences in later stages of life of the new-born. Since prenatal and postnatal exposures to different flavors determine the extent to which a child develops food preferences, it can be used as a baseline to ascertain positive nutritional status of children later in life. This knowledge can also be used to improve the development of good nutritional habits in children.

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## Conflicts of interest

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