Abstract
Children’s vegetable consumption falls below current recommendations, highlighting the need to identify strategies that can successfully promote better acceptance of vegetables. Recently, we described two promising approaches to increase the acceptance of vegetables: (a) offering infants a variety of vegetables (purée changed every day for 10 days vs. 3 days and no change) at the beginning of weaning increases acceptance of new foods, including vegetables, and (b) offering 7-month-old infants an initially disliked vegetable at 8 subsequent meals markedly increases acceptance for that vegetable. The first stage of the study showed that these different effects persisted for several weeks. In a follow-up study, at 6 years, observations in an experimental setting showed that children who had been breastfed and who had experienced high vegetable variety at the start of weaning ate more new vegetables and liked them more. They were also more willing to taste vegetables than formula-fed children or the no- or low-variety groups. The initially disliked vegetable was still liked by 57% of children. This brief review shows that experience with sensory variety in the context of breastfeeding, early experiences with vegetable variety during complementary feeding, and repeated experience with an initially disliked vegetable can influence food preferences and healthy eating habits into childhood.

Introduction
The first smile, the first step, the first word… We never learn as much as in our earliest childhood, and: What children learn in their first 1,000 days characterizes them for the rest of their lives. This period is a sensitive one for the develop-
ment of healthy eating habits, and, for this reason, interventions are likely to have a strong impact on health outcomes later during childhood and adulthood. Anyone setting the right course here lays the foundation for a healthy life. Be it growth, the immune system, or mental development, all benefit from a healthy diet.

The early development of taste and food pleasure plays an important role for children and has long-lasting influences on subsequent food preferences and choices [1, 2]. Eating a variety of foods is essential to achieve adequate coverage of macro- and micronutrients. However, children’s vegetable consumption often falls below current recommendations, highlighting the need to identify strategies that promote better acceptance of vegetables [3]. Apart from our innate liking for sweet foods and disliking for very bitter foods, sensory pleasure for foods is mostly acquired through our early eating experiences. Infants have a fine palate and more taste buds than adults when they are born. They have about 10,000 taste buds all around their tongue, including the roof, back, and sides of their mouth [4]. The flavors of what a mother eats while pregnant can reach the fetus and help set up flavor preferences later on [5, 6]. From birth, infants can taste and smell foods, an experience that can take place through human milk as the food eaten by the mother influences the flavor of her milk and, thereby, the child’s preference [7, 8]. Thus, preferences for specific flavors develop early through milk-related flavor exposure or even during pregnancy, allowing an easier acceptance of new flavors and textures. Breastfeeding favors the taste acquisition of a variety of foods [2, 9, 10]. This early experience serves as the foundation for the continuing development of food preferences across the lifespan and is shaped by the interplay of biological, social, and environmental factors.

At weaning, food preferences develop due to repeated exposure to a variety of foods, especially vegetables and fruits [10–13]. The persistence of these early influences seems to be long-lasting [1]. Factors favoring the development of food acceptance at the beginning of complementary feeding include, in particular, the role of early variety, repeated exposure, timing of food introduction, and sensory properties (texture, taste, and flavors).

With increasing age, the influence of a number of factors, such as peers, personal experience, family, and food availability, continue to mold food preferences and eating behaviors. During the 3rd year of life, most children enter a neophobic phase, during which the introduction of new foods becomes difficult [14]. However, habits of eating a variety of vegetables and foods acquired early in weaning appear to attenuate this neophobia [1].
A Spoon of Culture and Tradition

Young infants are far less fussy than the experience might suggest at the dining table. This shows the diversity of the various complementary food traditions around the globe. Eating habits and attitudes towards eating can be considered one of the most important aspects of a culture. Because of different cultural traditions, attitudes, and systems [15], the reasons for introducing complementary food may vary widely. The literature shows large differences in practice across the world in the timing of the onset of complementary feeding, and even within European cultures, practices are surprisingly varied [16].

When parents in Germany think of the first weaning food, they all think first about allergies. Does my child eat the carrot or is it better to start with the low-allergen parsnip? To be on the safe side, there is often a whole week then of parsnip until a new vegetable will be introduced. In the neighboring country France, the mothers are much more courageous. Almost every day there is a new vegetable introduced during weaning, even fish is introduced quite early and regularly [17]. The wider the perspective, the more confusing is the variety of complementary feeding traditions. While worried parents may be looking for the best solution for their child, experts advise one thing above all: relaxation. A baby’s nutritional needs can be met in many different ways. To provide guidance for parents, it makes sense for each country to develop its own recommendations on how children can grow up healthy with available resources, systems, and traditions. Whether it is fermented corn sorghum paste like in Nigeria, millet porridge with sour milk like in Senegal, or Thai rice porridge with bananas: infants can learn to like almost anything as long as their parents set a good example and demonstrate it to them.

Early Development of Sensory Experience

There is considerable evidence from controlled animal and human studies that sensory experiences early in life can influence flavor preferences and food acceptance [7, 18, 19]. This critical period starts with feeding through the umbilical cord during gestation, continues via oral feeding with milk, and then the complementary feeding begins, and the infant discovers a variety of foods and flavors. Humans generally have inborn positive responses to sugar and salt, and negative responses to bitter taste [20]. Genetically determined individual differences also exist and interact with experience to ensure that children are not genetically restricted to a narrow range of foodstuffs [21]. Children are also predisposed to prefer high-energy foods, to reject new foods, and to learn as-
sociations between food flavors and the postingestive consequences of eating [22].

Previous research showed that breastfed infants more rapidly accepted a new vegetable than formula-fed infants [9, 10, 23]. Breastfeeding is also associated with positive effects on later eating patterns and willingness to accept vegetables [1, 2, 24]. A longitudinal study was conducted in Germany and France to evaluate if children who had been breastfed liked a new vegetable more readily and were also more willing to taste vegetables than formula-fed children at the start of complementary feeding but also at the age of 6 years. It showed that at both time frames children who had been breastfed consumed more of the new vegetables and were more willing to taste vegetables [1, 10]. This positive effect of breastfeeding on food acceptance may be associated with the more varied flavor variety in breast milk, linked to the transfer of flavor compounds. Thus, in contrast to infant formula, mother’s milk provides a potentially rich and complex sensory experience for the infant, reflecting in part the mother’s eating habits and food culture [20]. The early flavor experience of formula-fed infants is markedly different from that of breastfed infants. Exclusively formula-fed children do not benefit from the ever-changing flavor profile of breast milk. Their flavor experience is more monotone and lacks the flavors of the foods of the mother’s diet. There are striking differences in flavors among the different types and brands of formulas, and formula-fed infants learn to prefer the flavors of the formula they are fed and foods containing these flavors [20]. This is indicated by a study on a milk substitute containing hydrolyzed proteins (hypoallergenic nutrition). This milk substitute for infants with a severe milk protein allergy has an unmistakably sour and bitter “burnt” taste. Infants who were fed this milk substitute for the first time at the age of 2 or 3 months accepted it even at the age of 7 months. However, if infants were offered this milk for the first time when they were 6 or 7 months old, they rejected it entirely [25]. Moreover, infants who were fed hydrolyzed baby milk for several months at a very early age were more willing to accept sour-tasting beverages when they were 4 or 5 years old [26].

A Spoon of Variety at Complementary Feeding – A Window of Opportunity

The complementary feeding period is a “window of opportunity” for acclimatizing infants to the taste of a wide variety of foods. Early learning about flavors continues during the complementary feeding period through the introduction of solids and changing exposures to a variety of new foods. In this particular time of the child’s life, there is the transition from breastfeeding/formula feeding to a complementary solid diet, and infants discover the sensory (taste, flavor, and texture) and nutritional properties (energy density) of the foods that will ulti-
mately compose their adult diet [27]. Infant acceptance of new tastes and flavors develops during the so-called “sensitive period” between 4 and 6 months [28]. This period is crucial in influencing the development of later food preferences. The period from 6 to 10 months is favorable for the introduction of more complex textures [28]. The early and easy acceptance of new foods at a slightly younger age in the period of the introduction of complementary foods (4–6 months) has been observed in many studies. It has been shown that the earlier fruits and vegetables were introduced, the better their acceptance both in infancy and at a later age in childhood. This possibly reflects the difficult nature in terms of texture and tastes shared by many fruits and vegetables, both properties which children find aversive. The only texture the infant has experienced before complementary feeding is thin, liquid, warm milk, and thus new textures like soft-cooked vegetables and even thick yogurt will feel wildly different. The oral motor skills are usually learnt between 6 and 12 months of age (the period in which the tongue learns to move solid food around the mouth in preparation for swallowing), and this ability is dependent upon the experience of textured food within the mouth rather than on any particular age or developmental stage [28].

It has been observed that if 12-month-old infants were given pureed and chopped carrots, they consumed more of the pureed carrots, but there was variability in the infants’ willingness to take the chopped carrots. The strongest predictor of the acceptance of chopped carrots at 12 months – other than the presence of teeth – was earlier experience with textured foods [29]. In addition, children who were used to a high variety of different foods in their diet ate more of the chopped carrots; this again reflects the generalization effect, the greater the experience, the greater the willingness to try. Furthermore, infants who are introduced earlier to lumpy foods tend to be easier to feed by their mothers than children introduced to lumpy solids after the age of 10 months. Children introduced to lumpy solids after the age of 10 months were reported as having more feeding problems at 7 years. They were also reported as eating fewer portions of fruits and vegetables at 7 years [30].

At the onset of complementary feeding, many infants dislike vegetables, and there are various reasons for this, including the taste, appearance, and texture, often influenced by how they are prepared. Being exposed to a variety of foods during the complementary feeding period helps modulate the acceptance of new foods, especially vegetables, in the first year of life and later on [1, 10, 11]. It has been shown that experience with a variety of vegetables (changing the vegetable offered each day) at the very onset of weaning increased intake of new foods a few weeks later [10] but also a few years later [1]. Breastfeeding and early experience with variety interacted, in that infants who had been breastfed and had then experienced a high variety of vegetables at weaning showed the most marked
acceptance of new foods [10]. In a follow-up study, it has been shown that the benefit of introducing a variety of vegetables maintains at least up to the age of 6 years [1]. At 6 years, children who had been exposed to a high level of variety consumed more of the new and known vegetables, were more willing to taste vegetables, and had higher liking scores for new or familiar vegetables [1].

At present, the first weaning food in many European countries (e.g., Germany), such as vegetables, potatoes, and meat, is thus increasingly competing with the variety and, following the Mediterranean model, also fatty sea fish. The long-held view that only 1 or 2 vegetables per week should be fed has become obsolete. Monotonous nutrition offers no protection against allergies and better food intake. On the contrary, infants who receive a varied complementary diet are also better and less complicated eaters later in life. Parents should, therefore, pay attention to a variety of fruits and vegetables at the beginning of the complementary feeding. Offering the infant a variety of flavors and textures from the start of complementary feeding is the best way to help them to enjoy a variety of foods as they grow up.

In conclusion, a preference for varied flavors should ultimately increase the range of nutrients consumed and the likelihood that a well-balanced diet is achieved. In other words, the variety effect may reflect an important adaptive mechanism in the regulation of food intake among omnivores.

**Repeated Exposure**

Despite the new freedom to introduce a variety of foods, many infants and young children are still unable to find the optimal nutritional mix. Vegetables may be rejected for a number of different reasons, from their bitter taste, unfamiliar texture, their relatively low energy content to simple lack of access in many families. Infants are born with about 10,000 taste buds and are, so to speak, real super-tasters at birth. Although they have a genetic preference for sweets, they also have an aversion to bitterness. Whether fennel, broccoli, or artichoke – even the smallest trace of bitter substances often does not escape the highly sensitive child’s palate. Thus, the following question emerges: Can children learn to like vegetables? What the infant tastes or does not taste is a question of training. Many parents give up here too soon. So, what to do when gourmet babies stubbornly resist something new? The most successful strategy to promote vegetable intake is repeated exposure [1, 12–14]. Repeated exposure to the pure/distinct taste of a vegetable during complementary feeding (on at least 8 occasions) can help infants learn to accept vegetables both immediately and in later childhood [1, 12]. So, if the baby does not eat a certain type of vegetable, it does not auto-
matically mean that they do not like it. At first, they only reject them because they do not know them. This is often misinterpreted. So, patience, patience – parents should not blame the child. It is a fundamental survival instinct that warns the little ones against new things. Patient repetition pays off. Parents should offer a new type of vegetable at least 8 times in a row. So, the baby gets used to its taste and learns to like the disliked vegetable.

Several research groups have observed that repeated exposure to a new vegetable, even one that is initially disliked, can lead to acceptance of that vegetable [12, 13]. For example, when a well-liked vegetable and an initially disliked vegetable were given to 7-month-old infants on alternate days over 16 days, by the 8th exposure to each, intake and liking of the 2 were similar [12]. In this study, mothers were asked to specify which vegetable purée their infants especially liked during the first months of taking solid foods or rejected so adamantly that the mothers no longer offered these foods to them. The mothers were then asked to offer their infants one vegetable daily – alternating between a vegetable the infants had initially rejected and one they had preferred – for 16 consecutive days. By the 8th exposure, the infants’ liking and intake of both vegetables was almost identical. Nine months later, 63% of the infants were still consuming and liking the previously disliked vegetable [12]. This persistence of increased acceptance was confirmed in children aged 6 years since 57% of the children continued to eat and like the initially disliked vegetable [1]. The importance of this effect has considerable practical implications. In the same regions in Germany and France where the repeated exposure study was conducted, if infants initially disliked a vegetable, most mothers (85%) offered it at no more than 2–3 subsequent meals before giving up and deciding not to offer it again [17]. Among the mothers reporting refusal, 6% said they immediately decided their infant definitively disliked the vegetable, 33% after 2 meals, 57% after 3–5 meals, and only 4% continued trying for longer. The results of those studies suggest that, rather than giving up after 2–3 tries, it is well worth offering an initially disliked vegetable up to 8–10 times without pressuring the child to eat it, because it is likely to be followed by adequate acceptance well into childhood.

Methods which mothers use to promote the intake of vegetables in their children are numerous. Strategies include seasoning, adding sauces or other liked foods, or even hiding vegetables. There is a lot of literature whether mixing or “masking” vegetables with other foods, a common way of preparing infant meals, enhances or reduces the positive effects of exposure on the development of acceptance for the masked vegetable [13]. Further research is required to explore whether specific combinations of foods and the prominence of the individual vegetable flavors (and visual characteristics) produce different outcomes for preference and intake. There is some evidence from a small sample of moth-
ers that mixing vegetable flavors (purées of cooked vegetable) with milk or baby rice can increase infants’ initial acceptance of vegetables and help bridge the transition from a diet of milk to the introduction of pure vegetable flavors [21].

Discussion and Conclusion

The prevalence of childhood obesity is rising, and multiple studies indicate that most of the risk factors develop during the early phases of life. These factors may range from the prenatal to the postnatal period. This brief review shows the importance of complementary feeding as a window of opportunity for the development of eating behaviors that can be maintained throughout childhood. The complementary feeding period is a “window of opportunity” to familiarize infants with a wide variety of foods because at this stage infants’ openness to trying new foods is at its peak, and familiar foods are likely to become preferred foods, and these acquired preferences tend to persist in later childhood.

Many children do not eat the currently recommended amounts of vegetables, and parents are frequently searching for practical ways to increase vegetable acceptance. The lack of the sweet flavor and the low energy density of many vegetables and some fruits mean that these foods may be rejected by children, and extra efforts may need to be put in place to help them accept these foods. Within this context, strategies to successfully promote better acceptance of vegetables should be identified. In spite of a huge body of literature, practical aspects and the results of their application are still poorly understood. This is due to the high complexity related to physiological mechanisms underlying early sensory experiences and the development of sensory preferences.

This review shows the effectiveness of breastfeeding, early experiences with vegetable variety during complementary feeding, and repeated experience with an initially disliked vegetable in promoting vegetable acceptance into childhood. The effects are long-lasting and provide the foundation for evidence-based recommendations to help parents promote healthy eating habits to their children. Current infant feeding guidance and practices suggest that this type of approach is not typical in many countries and that there is scope to provide parents and health care professionals with practical advice on encouraging vegetable acceptance during complementary feeding. The findings addressed in this review should be used in the design of future interventions targeting the prevention of childhood obesity.

Disclosure Statement

The author has no conflict of interest.
References


