

Eating a rainbow – improving liking and intake of vegetables from weaning

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The importance of vegetables in the diet

Vegetables are the most varied of the food groups, important providers of antioxidant and anti-inflammatory phytochemicals, vitamins and minerals. High vegetable intakes are associated with lower cancer, stroke and cardiovascular disease risk,¹⁻³ lower Body Mass Indices⁴ and the potential to prevent neurodegenerative disease.⁵ They form a key component to healthy eating⁶ and help to lower the energy density of the diet. Yet national survey data highlight low intakes in UK children⁷ and school-based interventions to increase fruit and vegetable intakes produce modest effects, increasing consumption by only a quarter of a portion per day.⁸ It would seem, therefore, that infancy may be an important time for an early introduction to vegetables with the dramatic transition to the family diet providing an important window of opportunity to establish good habits that can last a lifetime.

The discovery of a palate

Flavour exposure begins in the womb, with maternal diet influencing the taste of amniotic fluid consumed by the foetus, and this flavour transmission continues if the mother breast feeds.⁹ Infants are predisposed to like sweet tastes in preparation for their initial milk diet, while bitter, sour flavours are initially rejected.¹⁰ This poses a challenge for the introduction of many vegetables which tend to be bitter e.g. cruciferous vegetables, which is confounded by the natural neophobic tendencies which peak at age two years.

Improving liking and acceptance of vegetables

A study by Sullivan and Birch¹¹ demonstrated that repeatedly giving the same vegetable over ten occasions increased liking in infants. Liking was further heightened in those infants that had been breast fed and the authors concluded that this was as a result of exposure initially through mother's milk. Indeed, this was confirmed by Mennella *et al*¹² in their experiments looking at carrot liking and acceptance in infants following the introduction of carrot juice during pregnancy and lactation compared with infants receiving no exposure during this time. A dose response effect



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was found with intakes higher in those exposed from pregnancy. However, repeated exposure can increase acceptance regardless of whether the infant is breast or formula fed, suggesting that the initial benefit of flavour introduction through breast milk may be matched by experience even in formula fed infants (see Hausner).¹²

Very recent work by Hetherington *et al*¹³ has also explored the introduction of new flavours to infants via milk within the weaning period. Intervention infants were exposed to twelve daily exposures of four vegetables (one per day) via puree added to their usual milk, followed by twelve daily exposures to the puree added to cereal. The control groups received their usual milk and cereal. Both groups then received eleven daily exposures of vegetable puree followed by the introduction of a novel vegetable puree on day twelve. Intake and liking of vegetables was higher in the intervention group. The authors concluded that introduction to vegetables in a gradual step-by-step approach may be helpful in increasing liking and acceptance of vegetables, particularly those with bitter flavours.

Repeated exposure facilitates familiarity with a food and variety is valuable in enhancing acceptance of a new food or vegetable. Mennella *et al*^{14,15} have determined that variety between and within meals can increase liking for new flavours following an eight day exposure experiment. The impact of providing vegetable puree as a single

flavour or as part of varied vegetable flavours both within and between days was explored. Variety increased liking for new test vegetables at the end of the exposure period and demonstrated that the infants were able to distinguish and recognise flavours used within the experiment. A prospective study of French children (Lange *et al Submitted*) revealed that the acceptance of new foods, especially new vegetables and fruits, is positively predicted by the variety of foods provided during the first two months of weaning. Importantly, French children tested for their response to food variety between the ages of 2–3 years and again at aged 22 years demonstrated that the more varied their choices were in adulthood,¹⁶ suggesting that early introductions can influence later choices. These findings suggest that a combination of variety and repetition should be recommended at the start of complementary feeding. This is further supported by Barends *et al*¹⁷ who studied starting complementary feeding with vegetables versus fruit, with both groups receiving variety and repetition. Starting complementary feeding with a variety and repetition of vegetables resulted in higher vegetable intake than the group that started with fruit, immediately after the intervention and at the age of 12 months. Other studies have also shown increased intake of vegetables after starting complementary feeding with a variety and repetition of vegetables.^{18,19} The early weaning period therefore looks to be an important window of opportunity to increase liking and acceptance. Attempts to increase liking of vegetables later on, e.g. the pre-school age seem much more difficult.^{20,21}

Parental strategies at weaning

In addition to starting complementary feeding with variety and repetition of vegetables, the approach of mothers presenting a new flavour may also be important. If mothers do not like the food being offered, this dislike may be demonstrated in her style of feeding. Indeed role modelling of parents to promote vegetable consumption and healthy eating generally has been recommended as a method to ensure ongoing acceptance of healthy food habits.²²

Interestingly, attitudes and official advice to introducing complementary foods differ across countries.^{23,24} French mothers approach weaning

as a taste journey, appreciating that this period of introducing the infant to the family diet is a learning process and a critical milestone for development. Discovering tastes and gaining pleasure from food was their primary concern when interviewed.²⁴ They were also conscious that later rejection of foods like vegetables is likely as children get older but were aware of strategies to try and reduce this, such as repeated exposure and combining with familiar foods. In contrast, British mothers tended to mention healthy eating and a balanced diet as important outcomes of weaning not taste development, yet variety of vegetables at this time was relatively low and introduced by stealth.²⁵ This would suggest that British mothers understand the 'what' to try and introduce during complementary feeding, but may need some guidance on 'how' best to introduce vegetables for optimal intakes.

Other strategies to increase vegetable intakes

In addition to repeated exposure, variety and role modelling, other strategies used by parents to increase vegetable intakes have been tested for their efficacy. These include the introduction of a novel vegetable flavour with a flavour or food already liked by the infant (flavour-flavour learning FFL) or through its introduction as part of an energy rich combination (flavour-nutrient learning FNL). Comparisons have been made between mere exposure, FFL and FNL to determine the most effective method for increasing liking and acceptance for vegetables over a period of ten exposures. Studies across infancy and the pre-school years have shown that repeated exposure to the vegetable appears to be most effective at increasing vegetable intake compared with FFL and FNL, but pairing of a flavour with a sweet flavour or added energy does not greatly benefit intake.²⁶⁻²⁸

Increasing vegetable consumption in infancy through repeated exposure, variety and modelling, are clearly methods for promotion to parents to aid increased liking and intakes of vegetables from an early age. Familiarisation of flavours throughout pregnancy and subsequent breastfeeding are valuable first tastes, but variety and repeated exposure during weaning seem more powerful and are methods that enhance an infants' likelihood of consuming vegetables even if earlier exposure via breast milk has been limited. Parents need support in recognising that initial dislike is not predictive of refusal and that perseverance is a critical element of acceptability.

Acknowledgements

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Health professionals can support parents by:

- Explaining that it is ideal to start with single vegetables, and these can begin to be introduced mixed into a small amount of milk, especially some of the more bitter varieties.
- Describing the importance of variety and repeated exposure of vegetables within and between feeding occasions
- Emphasising that weaning is a flavour journey and tiny taste buds are developing. Taste, touch and smell are all important components – let baby explore the foods for themselves
- Helping parents to understand when baby has had enough – what do hunger and fullness cues look like? Discouraging coercive feeding.
- Showing parents or signposting them to sessions on how to prepare, cook and store vegetables if confidence is low i.e. local weaning clubs, cook and eat sessions etc.
- Sharing information on seasonal vegetables to assist with budgeting
- Skilling up if necessary on nutrition, diet and parenting to be able to assist parents knowledgeably and confidently.

Parents can support their child by:

- Eating healthily themselves and including a variety of vegetables during pregnancy and breast feeding
- Understanding that learning to eat and acceptance of new flavours and textures is a skill and takes time and patience like other areas of child development
- Accepting that rejection on the first try does not necessarily mean that the food offered is not liked. Repeating the exposure is more likely to increase liking and acceptance.
- Role modelling: weaning is the gradual move from a milk based diet to the family diet. Parents can help by eating the foods they want their children to eat.
- Preparing ahead for mess! Flavour journeys involve taste, smell and touch when babies can explore for themselves and mess is a part of the journey
- Creating an environment conducive to mindful eating i.e. no TV or other distractions whilst eating, sitting together to eat, making time for the occasion.
- Following hunger and fullness cues – allowing baby to determine the amount eaten, and to stop when they have had enough

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References

1. World Cancer Research Fund (2007). *Food, Nutrition, Physical Activity and the Prevention of Cancer: A Global Perspective*. World Cancer Research Fund/American Institute of Cancer Research, Washington DC.
2. He FJ, Nowson CA *et al* (2007). Increased consumption of fruit and vegetables is related to a reduced risk of coronary heart disease: meta-analysis of cohort studies. *J of Human Hypertension*, 21: 717-728.
3. Boeing H, Bechthold A *et al* (2012). Critical review: vegetables and fruit in the prevention of chronic diseases. *Eur J Nutr*, 51: 637-663.
4. Vioque J, Weinbrenner T *et al* (2008). Intake of fruits and vegetables in relation to 10-year weight gain among Spanish adults. *Obesity*, 16:664-670.
5. Donini LM, DeFelice MR & Cannella C (2007). Nutritional status determinants and cognition in the elderly. *Archives of Gerontology and Geriatrics*, 44: 143-153.
6. Food Standards Agency Eatwell Plate: <http://www.food.gov.uk/multimedia/pdfs/publication/eatwellplate0210.pdf>
7. *National Diet and Nutrition Survey: Headline results from Years 1, 2 and 3 (combined) of the Rolling Programme (2008/2009 – 2010/11)*. A survey carried out on behalf of the Department of Health and the Food Standards Agency, London, UK.
8. Evans CEL, Christian MS *et al* (2012). Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12y. *AJCN*, 96:889-901.
9. Mennella JA, Jagnow CP *et al* (2001) Prenatal and Postnatal Flavor Learning by Human Infants. *Pediatrics*, 107: e88.
10. Cowart B (1981). Development of taste perception in humans: sensitivity and preference throughout the life span. *Psychol Bull* 90:43-73.
11. Sullivan SA, Birch LL (1994). Infant dietary experience and acceptance of solid foods. *Pediatrics* 93:271-277.
12. Hausner H, Nicklaus S, *et al* (2010). Breastfeeding facilitates acceptance of a novel dietary flavour compound. *Clin Nutr.*, 29:141-148.
13. Hetherington M, Schwartz C *et al* (2013). A step-by-step introduction to vegetables at the beginning of weaning: the effects of early and repeated exposures. *VIVA International Congress*, March 2013.
14. Gerrish CJ & Mennella J (2001). Flavor variety enhances food acceptance in formula-fed infants. *AJCN*, 73: 1080-1085.
15. Mennella J, Nicklaus S, *et al* (2008) Variety is the spice of life: Strategies for promoting fruit and vegetable acceptance during infancy. *Physiology & Behavior*, 94: 29-38.
16. Nicklaus S, Boggio V *et al* (2005). A prospective study of food variety seeking in childhood, adolescence and early adult life. *Appetite*, 44:289-97.
17. Barends c, de Vries J *et al* (2013). The effects of weaning with either fruits or vegetables at the age of 4-6 months on vegetable and fruit acceptance at 12 and 23 months. *VIVA International Congress*, March 2013.
18. Maier AS, Chabanet C *et al* (2008). Breastfeeding and experience with variety early in weaning increase infants' acceptance of new foods for up to two months. *Clin Nutr*. 27:849-857.
19. Lange C, Visalli M *et al* (2013). Description of maternal feeding practices and their impact on infant's acceptance of new foods. *VIVA International Congress*, March 2013.
20. Zeinstra GG & Kooijman V (2013). The effect of three learning techniques on Dutch children's vegetable consumption. *VIVA International Congress*, March 2013.
21. Cecil J, Wilson M *et al* (2013). It's never too late to learn – applying learning theory to improve liking and intake of vegetables in pre-school age children. *VIVA International Congress*, March 2013.
22. Rudolf M (2009). *Tackling Obesity through the Healthy Child Programme, A Framework for Action*. Department of Health, London.
23. Schwartz C, Scholtens, *et al* (2011). Development of healthy eating habits early in life: review of recent evidence and selected guidelines. *Appetite*, 57, 796-807.
24. Schwartz C, Scholtens P *et al* (2013). Complementary feeding: comparison and evaluation of national and international guidelines. *VIVA International Congress*, March 2013.
25. Caton S, Ahern, & Hetherington M (2011). Vegetables by Stealth: an exploratory study investigating the introduction of vegetables in the weaning period. *Appetite*, 58: 816-825.
26. Hausner H, Olsen A, Møller P (2012). Mere exposure and flavour-flavour learning increase 2-3 year-old children's acceptance of a novel vegetable. *Appetite*, 58: 1152-1159.
27. Remy E, Issanchou S *et al* (2013). Comparison of repeated exposure, flavor-flavor learning, and flavor-nutrient learning to increase artichoke intake in weaning infants. *VIVA Internationl Congress*, March 2013.
28. Caton S, Ahern SM *et al* (2012). Repetition counts: repeated exposure increases intake of a novel vegetable in UK pre-school children compared to flavour-flavour and flavour-nutrient learning. *Br J Nutr*. 30:1-9. [Epub ahead of print]