Clinical Nutrition (2008) **27**, 849–857

available at www.sciencedirect.com

ScienceDirect

http://intl.elsevierhealth.com/journals/clnu

ORIGINAL ARTICLE

Breastfeeding and experience with variety early in weaning increase infants' acceptance of new foods for up to two months☆

Andrea S. Maier [a,b,c,*], Claire Chabanet [b], Benoist Schaal [c], Peter D. Leathwood [a], Sylvie N. Issanchou [b]

[a] *Nestlé Research Center, CH-1000 Lausanne, Switzerland*
[b] *INRA, UMR 1129 FLAVIC, F-21000 Dijon, France*
[c] *Centre Européen des Sciences du Goût, UMR 5170, CNRS, Université de Bourgogne-INRA, F-21000 Dijon, France*

Received 3 April 2008; accepted 3 August 2008

KEYWORDS
Infant;
Complementary feeding;
Breastfeeding;
Flavour variety;
Food acceptance

Summary
Background & aims: Previous studies showed that (1) breastfeeding and (2) higher food variety early in weaning can increase acceptance of new foods for the next few days. Here we measure, in two European regions, effects of breast or formula feeding and experience with different levels of vegetable variety early in weaning on new food acceptance during two months following the start of weaning.
Methods: Breast- or formula-fed infants received their first vegetable (carrot purée) and, over the next 9 days, either carrots every day; 3 vegetables changed every 3 days; or 3 vegetables changed daily. On the 12th and 23rd days they received new vegetable purées, zucchini–tomato then peas. Several weeks later, they received 2 more new foods, meat and fish. Acceptance of new foods was measured by quantities eaten and by liking ratings.
Results: Breastfeeding and variety early in weaning increased new food acceptance. Frequency of change was more effective than number of vegetables fed. The *combination* of breastfeeding and high variety produced greatest new food intake. This effect persisted 2 months later.

☆ Part of this work was presented at the paediatric conference (''Transition from milk to food'') held in Obergurgl, Austria, 2–6 March 2008 and at the 17th meeting of the European Chemoreception Research Organisation (ECRO) held in Grenada, Spain, 4–8 September 2007.

* Corresponding author. Nestlé Research Center, Food Consumer Interaction, P.O. Box 44, Vers-chez-les-blanc, CH-1000 Lausanne 26, Switzerland. Tel.: +33 41217858979; fax: +33 41217858554.
E-mail address: andrea.maier@rdls.nestle.com (A.S. Maier).

doi:10.1016/j.clnu.2008.08.002

Conclusions: These interventions correspond to differences in milk and vegetable feeding observed in the regions studied suggesting that the results have practical consequences for acceptance of new foods.

Introduction

Previous research showed that, at the start of weaning, breast-fed infants more rapidly accepted a new vegetable purée than formula-fed infants[2] and experience with a variety of vegetables at the start of weaning increased intake of a new food 2 days later.[3] If these effects lasted for weeks or months, then they might provide a base for enhanced acceptance for a wider range of vegetables and perhaps other foods later on. In addition, the combination of breastfeeding and early flavour variety might produce greater or longer-lasting increases in acceptance of new foods. In this paper, we describe the effects of and interaction between these 2 factors on intake of and liking for new foods over the 2 months following the start of weaning.

In an earlier study[1] we observed that mothers in Aalen (Germany) tended to breastfeed longer than did mothers in Dijon (France), although a range in length of breastfeeding was observed in both regions. In Aalen, mothers also tended to offer far fewer vegetables and less frequent changes in vegetables during the first weeks of weaning than did mothers in Dijon (France). The present study was carried out in Aalen and in Dijon and the range of variety experiences studied is within that found in the 2 regions. One of the variety regimens, 3 vegetables each given for three consecutive days was included in part because some health professionals recommend offering infants a new food on 3 successive days in order to check for allergic reactions.[4] We wanted to know if this type of ''variety experience'' was as efficient in increasing acceptance of new foods as the same 3 vegetables changed daily.

Methods

Experimental design

The factors studied were: type of milk feeding and experience with variety of vegetables early in weaning. The 2 levels of milk feeding were formula-fed (breast-fed < 15 days) and breast-fed (breast-fed for > 30 days). The 3 levels of variety experience were 1 vegetable (0 changes: C0), carrot purée (Ca) given each day for 10 consecutive days; 3 vegetables (4 changes: C4), a first meal of carrot purée followed by artichoke purée (Ar), green beans (Gb), and then pumpkin (Pu) each given for 3 consecutive days; and 3 vegetables (10 changes: C10), carrot purée followed by the same 3 vegetables but with daily changes.

The design (Fig. 1) consisted of 3 Phases (Phases A, B, and C). During Phase A (days 1–12), on the first day, all infants were given carrot purée (Ca), fed in the laboratory. Over the next 9 days, the 3 variety groups received different patterns of vegetable feeding (see above). On days 11 and 12, mothers brought their infant to the laboratory and gave, on day 11, carrot purée and, on day 12, a new vegetable, zucchini–tomato purée (ZT).

In Phase B (days 13–23) for 10 days, each mother offered her child, at home, on alternate days, the new vegetable ZT and carrots (Ca) and on day 23, returned to the laboratory and gave her infant a second new vegetable, pea purée (Pe).

Each mother decided independently when to begin meat and fish (Phase C) so, after a variable delay (mean $\pm$ SEM: 21.7 ± 1.8 days), offered the first meat purée (Me) in the

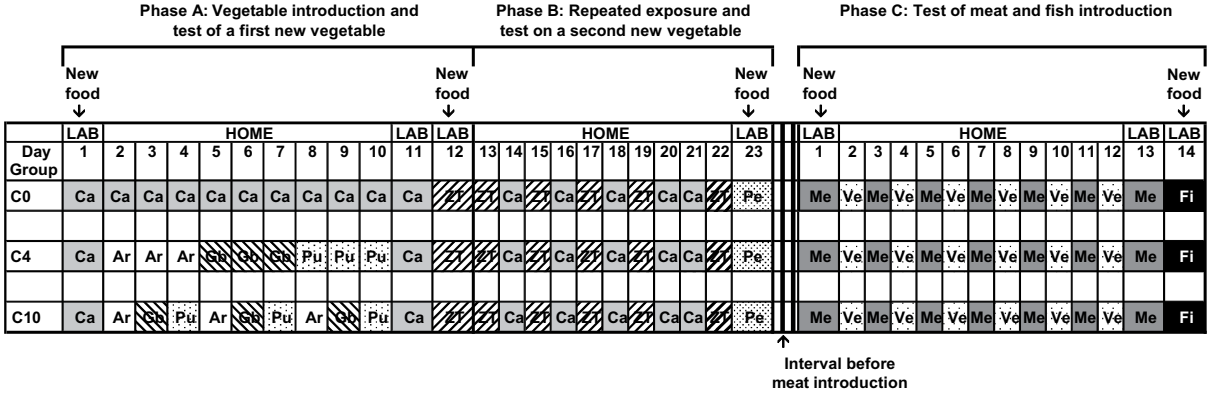

Figure 1 Experimental design showing the new foods given (vegetables, meat and fish) on each of the 3 Phases (Phases A, B and C) of introduction of weaning foods to the 3 groups of infants: C0 = carrot group (no changes), C4 = low variety group (4 changes), and C10 = high variety group (10 changes). On days 1, 11, 12, 23 and meat day 1, meat day 13 and fish day 14, infants were fed by their mothers in the laboratory. On days 2–10, 13–22 and meat days 2–12 they were fed at home. Ca = carrot purée; Pu = pumpkin purée; Ar = artichoke purée. New foods introduced the first time of infants' life after the intervention period (Phase A at home) were ZT = puréed zucchini–tomato mix (day 12), Pe = puréed peas (day 23), Me = meat purée (Phase C, day 1), Fi = Fish purée (Phase C, day 14).

laboratory. For the next 11 days, she offered, at home, on alternate days, meat purée and a vegetable purée of her choice. On days 13 and 14, she returned to the laboratory and gave her infant meat purée again (day 13) and, on day 14, a 4th new food, fish purée (Fi).

The 3 groups were, as far as possible, balanced in terms of breast and formula feeding, sex and maternal parity.

Subjects and ethics

Mothers with infants having no illness or allergy who had not begun to give vegetables were recruited using flyers posted at local hospitals, paediatric practices, day-care centres, and nurseries, asking them to contact the team by telephone if interested to participate in a study of infant feeding practices. The study was approved in both countries by the local ethics committee (C.C.P.P.R.B. in Dijon; *Landesärztekammer* in Aalen) and participating mothers signed an informed consent form.

In all, 147 mother–infant pairs participated in Phases A and B. Infants' age at the start of the study was (mean ± SEM: 5.2 ± 0.1 months) consistent with previously reported ages for start of vegetable feeding in both regions.[1] Forty-five Dijon and 38 Aalen infants were breast-fed for at least one month (mean ± SEM: 3.9 ± 0.2 months and 4.6 ± 0.3 months, respectively) while 27 Dijon and 37 Aalen infants were formula-fed. In Phase C (meat and fish), 143 of the mother–infant pairs participated. At the end of the study, mothers received a 70€ voucher.

Procedure

About 10 days before the start of the study, the procedure was explained to each mother as follows:

1. Throughout the study, the same person should feed the infant the experimental foods, in the laboratory and at home. (This was almost always the mother so this person is hereafter referred to as ''the mother'').
2. To limit influences of mothers' facial or verbal expressions on infant behaviour, mothers were instructed to keep a neutral face and remain silent while feeding. Preliminary tests showed that mothers spontaneously opened their mouth as they offered the spoon, so each mother was instructed to open her mouth as she offered the spoon.
3. We also observed that touching the infant's lips with the spoon often led to mouth opening, so each mother was instructed, at each meal, to touch her infant's lips the first three times she offered the spoon but

Table 1 Subjects' characteristics: Dijon

	Breast-fed infants (>30 days)			Formula-fed infants (<15 days)		
	C0	C4	C10	C0	C4	C10
Mothers' characteristics						
Age (yrs)	29.3 ± 1.1[a]	29.4 ± 1.0	29.3 ± 0.6	30.1 ± 1.3	31.3 ± 1.4	29.9 ± 1.1
BMI (kg/m^2)	23.5 ± 1.3	21.8 ± 0.5	23.6 ± 0.9	23.7 ± 1.3	24.3 ± 2.1	23.2 ± 1.4
Primi/Multiparous (*n*)	10/8	6/6	7/8	3/5	3/6	5/5
Neophobia[b, c]	24.1 ± 1.7^A	27.3 ± 2.7^{AB}	25.8 ± 3.0^A	35.5 ± 4.9^B	22.3 ± 3.0^A	22.2 ± 3.0^A
Varseek[d]	41.6 ± 1.8	42.8 ± 2.5	39.1 ± 2.6	35.6 ± 3.5	39.2 ± 2.5	42.7 ± 2.4
Anxiety trait[e]	39.6 ± 1.7	39.2 ± 2.5	40.4 ± 2.0	37.4 ± 2.2	40.6 ± 3.3	39.6 ± 2.7
Infants' characteristics at the beginning of Phase A – introduction of vegetables						
N	18	12	15	8	9	10
Boys/Girls (*n*)	8/10	6/6	7/8	5/3	7/2	6/4
Age (months)	5.2 ± 0.2	5.1 ± 0.3	5.5 ± 0.2	5.7 ± 0.5	5.0 ± 0.2	4.9 ± 0.2
Weight (kg)	6.7 ± 0.2	6.9 ± 0.2	7.0 ± 0.2	7.3 ± 0.5	6.8 ± 0.2	6.9 ± 0.2
Breastfeeding (days)	126.3 ± 11.6	111.8 ± 14.8	108.5 ± 12.7	1.8 ± 1.7	3.9 ± 2.1	3.5 ± 1.9
Infants' characteristics at the beginning of Phase C – introduction of meat						
N	17	12	15	7	9	9
Age (months)[c]	6.5 ± 0.2^A	6.9 ± 0.3^{AB}	7.3 ± 0.3^{AB}	7.9 ± 0.5^B	7.1 ± 0.5^B	6.6 ± 0.3^A
Weight (kg)	7.6 ± 0.3	7.8 ± 0.2	8.2 ± 0.3	8.5 ± 0.4	8.0 ± 0.3	7.9 ± 0.4
Breastfeeding (days)	152.2 ± 15.6	141.0 ± 22.7	122.1 ± 17.0	2.0 ± 2.0	3.9 ± 2.1	3.9 ± 2.1
Infants' temperament						
Difficult	2.8 ± 0.2	3.4 ± 0.3	3.0 ± 0.3	3.2 ± 0.2	3.0 ± 0.1	2.9 ± 0.2
Unadaptable	2.5 ± 0.2	2.2 ± 0.3	2.1 ± 0.3	2.0 ± 0.2	1.8 ± 0.3	2.2 ± 0.4
Unresponsive	2.0 ± 0.2	1.9 ± 0.2	1.7 ± 0.1	1.7 ± 0.3	1.9 ± 0.3	1.5 ± 0.2
Unpredictable	2.9 ± 0.2	3.1 ± 0.2	2.5 ± 0.3	3.0 ± 0.3	2.9 ± 0.4	2.7 ± 0.1

[a] Mean ± SE.
[b] Possible range of scores for neophobia scale: 10–70.
[c] Means with a different letter are significantly different.
[d] Possible range of scores for varseek scale: 8–56.
[e] Possible range of scores for anxiety trait: 20–80.

thereafter hold it 2–3 cm away from her infant's mouth and wait until it was accepted or refused.
4. Mothers were instructed to feed at their customary pace until the infant refused the spoon on 3 consecutive occasions.[2,3] ''Refusal'' included keeping the mouth closed, turning away, pushing the spoon away, crying, or playing.
5. No additional vegetables should be given during the first 23 days of the study (i.e. during Phases A and B).
6. To facilitate interpretation of the video recordings, mothers were instructed to use a spoon with a slightly bent back handle (so the mother's hand did not obscure the infant's face from the camera). Mothers were given the spoon 1–2 weeks before the study began so they could practice using it with milk or water.

During laboratory feeding sessions, 390 g of baby food (the content of 3 jars) was placed in a bowl, heated to 40 °C in a microwave oven, weighed, and then given to the mother to feed to her infant. After the infant had refused 3 consecutive spoons, all food spilled onto the tray was returned to the bowl, which was weighed again. The infant's bib was weighed before and after feeding and the difference also used in calculating weight of food consumed.

Infant food diary. Throughout the study, each mother kept a diary noting the foods and drinks given to her infant.

Mothers' and infants' characteristics. Mothers completed the following questionnaires: the Food Neophobia Questionnaire,[5] the Variety-Seeking Tendency Questionnaire with respect to foods,[6] the Anxiety Trait Questionnaire,[7] and the Infant Characteristics Questionnaire.[8] Where necessary, questionnaires were translated into French and German and then back-translated to check precision.

Foods

The choice of foods offered was based on results of an earlier weaning practices questionnaire study in the 2 regions,[1] which showed that mothers generally considered all the purées used here were plausible foods to offer infants at that stage of feeding. Foods were prepared at the Nestlé Product Technology Center, Singen, Germany or the factory in Epinal, France. Two batches of each purée were prepared, one for Dijon, the other for Aalen. All vegetable purées contained 205–217 kJ/100 g, the meat purée

Table 2 Subjects' characteristics: Aalen

	Breast-fed infants (>30 days)			Formula-fed infants (<15 days)		
	C0	C4	C10	C0	C4	C10
Mothers' characteristics						
Age (years)	30.1 ± 0.8[a]	34.6 ± 1.3	32.5 ± 1.3	29.9 ± 1.5	29.8 ± 1.3	31.8 ± 1.2
BMI (kg/m^2)	23.7 ± 1.1	23.7 ± 0.9	26.0 ± 1.5	24.8 ± 1.2	28.7 ± 2.1	25.3 ± 1.2
Primi/multiparous (*n*)	6/6	6/9	6/5	4/9	5/6	5/8
Neophobia[b]	34.5 ± 2.6	32.5 ± 2.3	37.8 ± 3.1	35.6 ± 3.7	32.6 ± 2.5	30.9 ± 2.8
Varseek[c]	30.3 ± 3.1	33.9 ± 2.1	35.0 ± 2.8	29.2 ± 3.2	41.5 ± 2.0	31.6 ± 3.3
Infants' characteristics at the beginning of Phase A – introduction of vegetables						
Anxiety trait[d]	34.9 ± 2.0	35.0 ± 2.5	38.7 ± 2.0	35.5 ± 3.2	37.5 ± 2.3	35.6 ± 2.6
N	12	14	12	13	11	13
Boys/Girls (*n*)	6/6	6/8	6/6	7/6	6/5	7/6
Age (months)[e]	5.4 ± 0.2	5.8 ± 0.3	5.2 ± 0.2	4.5 ± 0.2	5.1 ± 0.3	4.8 ± 0.3
Weight (kg)	6.9 ± 0.3	6.9 ± 0.3	7.0 ± 0.30	7.2 ± 0.2	7.1 ± 0.2	7.8 ± 0.3
Breastfeeding (days)[f]	109.6 ± 15.1^A	157.4 ± 12.5^B	142.7 ± 8.2^{AB}	1.1 ± 1.1	2.6 ± 1.4	3.2 ± 1.7
Infants' characteristics at the beginning of Phase C – introduction of meat						
N	12	13	12	13	11	13
Age (months)[e]	6.7 ± 0.1	7.0 ± 0.3	6.6 ± 0.2	5.8 ± 0.3	6.4 ± 0.3	5.9 ± 0.2
Weight (kg)	7.6 ± 0.3	7.8 ± 0.3	8.2 ± 0.4	7.9 ± 0.3	7.7 ± 0.2	8.3 ± 0.4
Breastfeeding (days)[f]	126.0 ± 19.2^A	185.1 ± 13.7^B	174.2 ± 11.5^B	1.1 ± 1.1	2.6 ± 1.4	3.2 ± 1.7
Infants' temperament						
Difficult	3.6 ± 0.3	3.5 ± 0.3	3.7 ± 0.3	3.6 ± 0.3	3.5 ± 0.4	3.7 ± 0.2
Unadaptable	2.9 ± 0.2	2.4 ± 0.2	2.5 ± 0.2	3.3 ± 0.4	2.4 ± 0.4	2.4 ± 0.2
Unresponsive	2.3 ± 0.1	2.0 ± 0.2	2.2 ± 0.2	2.3 ± 0.3	2.0 ± 0.2	2.0 ± 0.3
Unpredictable	2.6 ± 0.2	2.5 ± 0.2	2.5 ± 0.3	2.6 ± 0.2	2.5 ± 0.3	2.4 ± 0.2

[a] Mean ± SE (all such values).
[b] Possible range of scores for neophobia scale: 10–70.
[c] Possible range of scores for varseek scale: 8–56.
[d] Possible range of scores for anxiety trait: 20–80.
[e] There was a significant difference for infants' age between the breast- and formula-fed infants at the beginning of Phase A ($p = 0.002$) and at the beginning of Phase C ($p = 0.0003$).
[f] Means with a different letter are significantly different.

(turkey) 288 kJ/100 g and fish (monkfish), 234 kJ/100 g. They were stored in 130 g jars labelled with the name of the food, the ingredient list, the ''use by'' date, the chief investigator's and sponsor's names and the study reference number. Sensory profiles of all purées were established using a trained sensory panel at Singen (see Supplementary data). The only clear difference between batches was that the pea purée offered in Dijon was thicker, less sweet and more bitter than in Aalen.

All purées were appropriate for ''Stage 1 or 2'' infants and conformed to EU requirements concerning composition of foods for infants (Commission Directive 2006/125/EC).

Statistical analysis

Subject characteristics. In each region, mother and infant characteristics were compared between breast- and formula-fed groups and among the 3 variety groups using analyses of variance (ANOVA) for the continuous variables (mothers' age, BMI, breastfeeding duration, and infants' weight and height of infants, neophobia, variety seeking or anxiety scores and infants' temperament) and Chi-squared tests for the categorical variables (gender and mothers' parity).

Experience with food variety during the transition period. During the period between Phases B and C, variety of foods offered was evaluated using the food diaries completed by the mothers. We calculated the number of different foods eaten each day and the number of changes from one day to the next. We then calculated the total number of foods (*sumvarfood*), and daily changes (*sumchangefood*). These were used as indices of food variety experienced during the transition period. In each region, we compared the values of these indices between breast- and formula-fed groups and among the 3 variety groups using ANOVA.

Food acceptance. For each infant during each laboratory session, we measured intake of food (g). In addition, the mother and an observer (the assistant at the feeding session) rated how much they thought the infant had liked the meal using a 9-point scale anchored at 1 = ''did not like at all'' to 9 = ''liked very much''. Thus 3 dependent variables related to food acceptance were analyzed.

The first meal (day 1) occurred before the variety experience and was the first time each infant in the study was fed a vegetable. An analysis of variance was conducted to determine if the breast- and formula-fed groups or the 3 experimental groups (C0, C4 and C10) differed in their acceptance of carrots on day 1. The model included the region effect and all 2-way interactions.

For each of the three dependent variables a repeated measures' analysis of variance using mixed model methodology was performed to determine if there were significant influences of breast vs. formulafeeding, early variety experience or region, on new food acceptance. The ''unstructured'' covariance option, making no assumption regarding equality of variances among measures, was selected. The model included 4 main effects (type of milk feeding; early variety experience; region; and new food) and all 2- and 3-way interactions that were significant for at least one variable.

All the statistics were carried out with SAS statistics software (SAS Institute Inc., Cary, NC, USA).

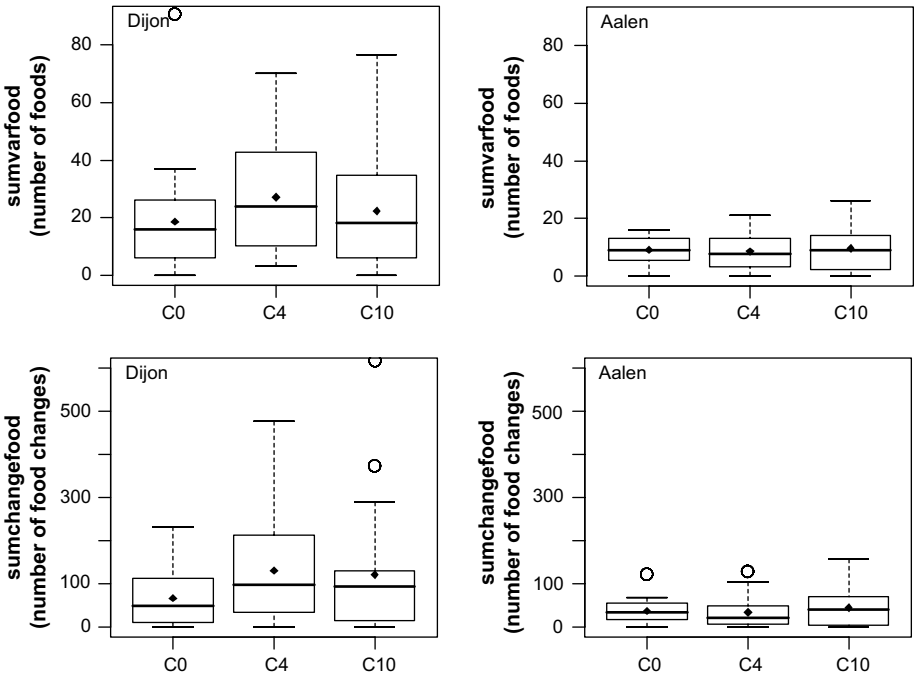

Figure 2 Box-plots of the total number of different foods (*sumvarfood*) and of food changes (*sumchangefood*) over the transition period between Phases B and C measured from the food diaries completed by the mothers in Dijon and Aalen. Medians, interquartile ranges, and full ranges are shown. No significant differences were observed between groups within each region.

Results

Subject characteristics

The characteristics of mothers and infant in Dijon and Aalen in the 2 milk feeding groups and the 3 experimental groups are shown in Tables 1 and 2.

Subject characteristics were similar in the 2 regions except that mothers in Aalen were slightly older ($p = 0.03$), had higher BMI's, higher neophobia, lower anxiety trait scores, lower variety-seeking scores, and rated their infants as more difficult, less adaptable and less responsive than those in Dijon ($p < 0.01$ for each comparison).

As mothers decided when they would introduce meat and fish, the time between offering the second new vegetable (peas) and the first meat varied. It was longer ($p < 0.0001$) and more variable in Dijon (29.2 days $\pm$ 95% CI: 6.5) than in Aalen (14.3 ± 2.6). In both regions, duration of the transition period and values of the 2 diet variety indices (*sumvarfood* and *sumchangefood*) were similar for breast- and formula-fed infants and among the 3 experimental groups. The index *sumchangefood* (Fig. 2) was more variable and higher ($p < 0.0001$) in Dijon than in Aalen. This was mainly due to the more variable and longer duration of the transition period. However, it was not the only reason since the difference for the mean number of food changes between the 2 regions was also significant ($p = 0.05$).

Acceptance of carrot (day 1)

Intake of carrot on day 1 did not differ significantly between breast- and formula-fed infants ($38.2 \pm 95\%$ CI: 8.0 vs. 31.8 ± 9.2) or among the variety groups (C0 = 31.7 ± 10.4, C4 = 30.4 ± 10.8, C10 = 42.9 ± 10.3). Liking for carrot on day 1 rated by mothers differed significantly ($p = 0.02$) between

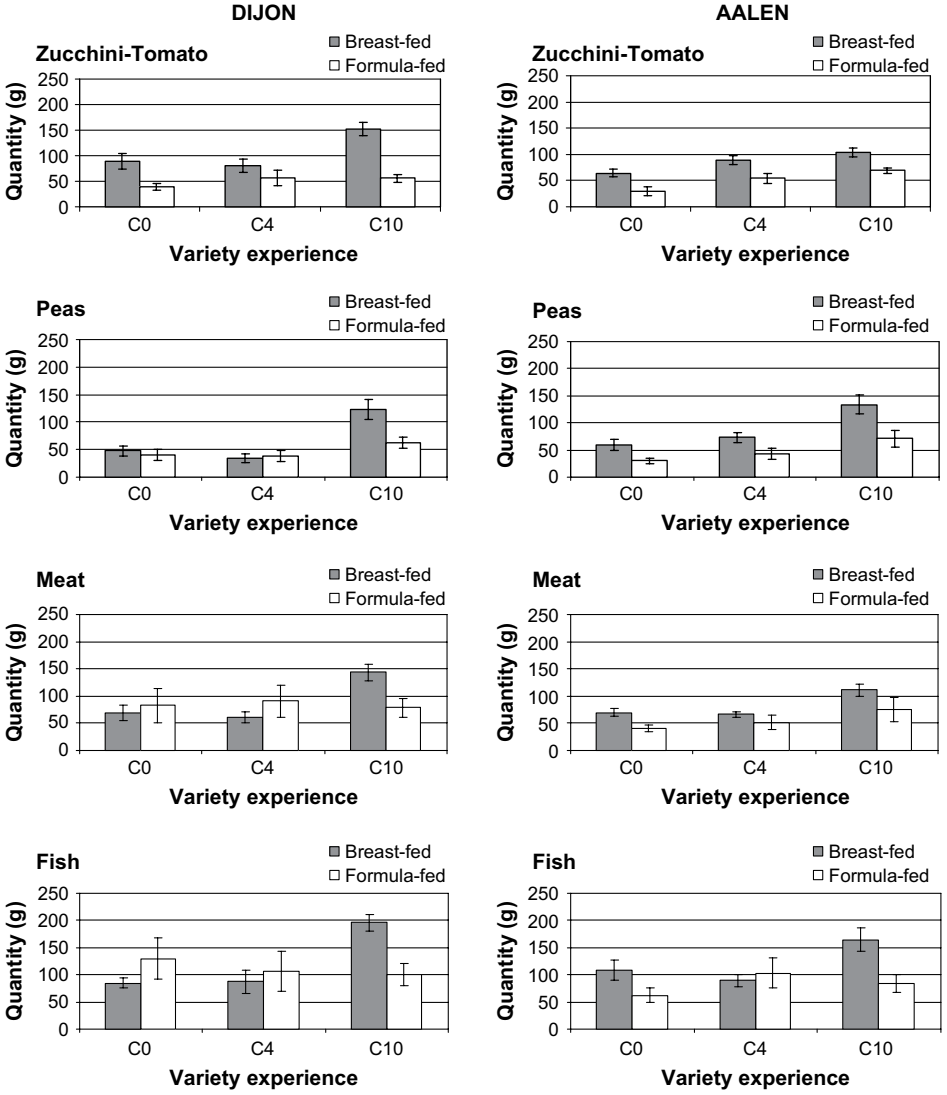

Figure 3 Effect of milk feeding (breast or formula) and experience with vegetable changes early in weaning on intake (mean $\pm$ SEM) for the two new vegetables, meat and fish in Dijon and Aalen. C0 (0 changes) = carrot purée for 9 days, C4 (4 changes) = low variety group with 3 different purées (artichoke, pumpkin and green beans) each given for 3 consecutive days, and C10 (10 changes) = high variety group with the same 3 purées, but with a change every day.

breast- and formula-fed infants (6.3 ± 0.5 vs. 5.4 ± 0.5) and between the C0 group and both the other groups (C0 = 5.1 ± 0.6, C4 = 6.5 ± 0.6, C10 = 6.0 ± 0.6; $p = 0.01$). Liking rated by observers did not differ significantly between breast- and formula-fed infants (5.5 ± 0.4 vs. 5.2 ± 0.5) but did differ significantly between the C0 group and both other groups (C0 = 4.7 ± 0.5, C4 = 5.6 ± 0.5, C10 = 5.7 ± 0.5; $p = 0.02$).

Effect of breastfeeding and vegetable variety on acceptance of new foods

Breastfeeding was associated with higher intake of the 4 new foods ($p < 0.0001$). There was also a significant effect of type of variety experience ($p < 0.0001$) with high vegetable variety (C10) producing the greatest increase in intake of new foods. There was a significant interaction ($p = 0.0009$) between type of milk feeding and type of variety experience because the *combination* of breastfeeding and high variety was associated with greatest intake of new foods (Fig. 3).

Breast-fed infants' liking was rated higher by mothers and observers ($p = 0.005$ and $p = 0.008$, respectively). There was also a significant effect of variety experience with high variety (C10) producing the highest liking scores from both mothers and observers ($p < 0.0001$). There was, however, no interaction between type of milk feeding and type of variety experience for liking ratings (Figs. 4 and 5).

For intake, there was a significant interaction between type of milk feeding and food ($p = 0.02$) with a larger and significant difference between breast- and formula-fed infants for zucchini—tomato and for peas, compared to meat or fish, introduced later. This effect was more marked

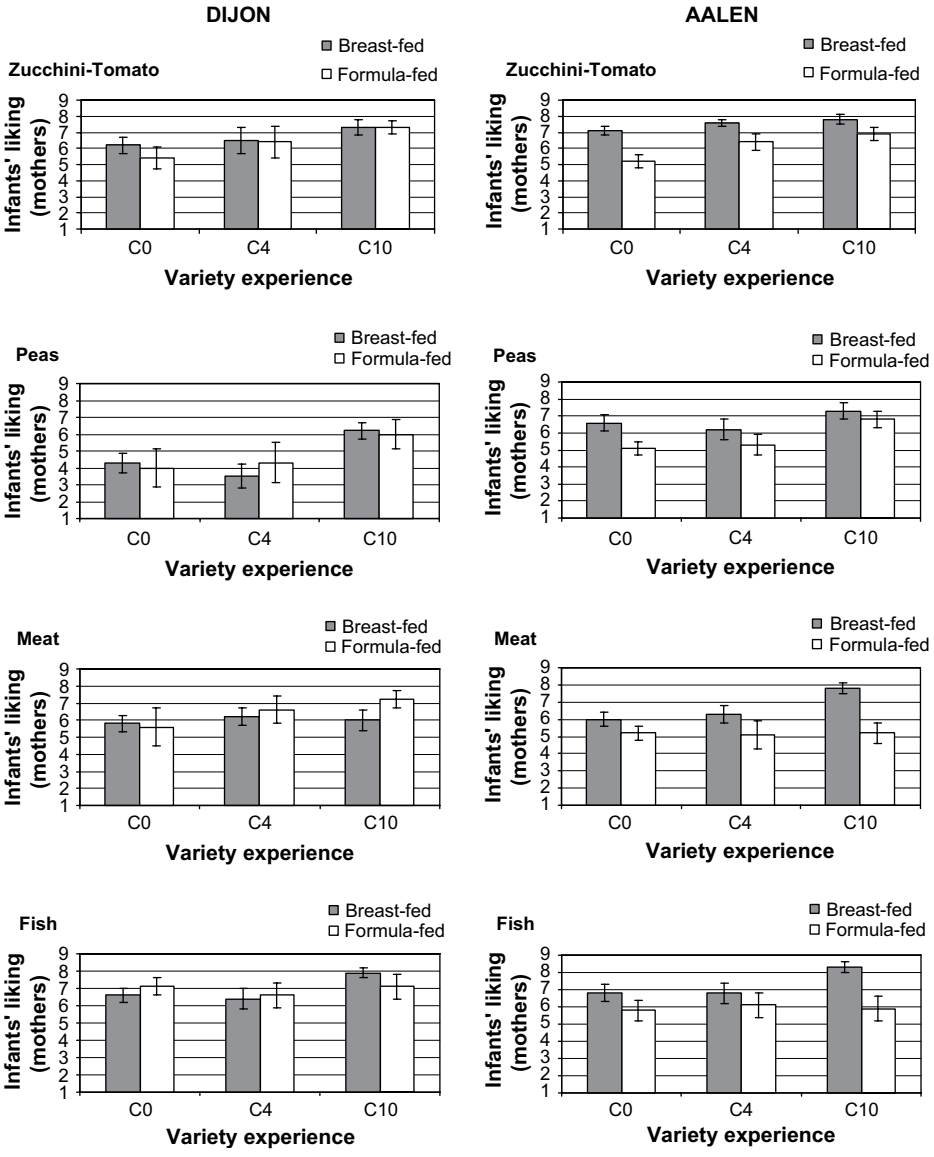

Figure 4 Effect of milk feeding (breast or formula) and experience with vegetable changes early in weaning on liking ratings given by mothers (mean ± SEM) for two new vegetables, meat and fish in Dijon and Aalen. C0 (0 changes) = carrot purée for 9 days, C4 (4 changes) = low variety group with 3 different purées (artichoke, pumpkin and green beans) each given for 3 consecutive days, and C10 (10 changes) = high variety group with the same 3 purées, but with a change every day.

in Dijon (interaction region *by* type of milk feeding *by* variety group, $p = 0.05$). This interaction was not observed for liking.

For liking, congruency between mothers' and observers' ratings was high, with 72.4% of the ratings differing by 1 or less on the 9-point scale. There was also a significant interaction between type of milk feeding and region ($p = 0.003$ and $p = 0.002$, for mothers' and observers' ratings, respectively) with breast-fed infants in Aalen liking new foods more than formula-fed infants while in Dijon liking ratings for the two groups were similar (Figs. 4 and 5).

There was also a significant new food effect on the three acceptance measures ($p < 0.0001$, for intake and for mothers' and observers' liking ratings) with highest acceptance for fish. There was a significant region *by* food interaction ($p = 0.01$, $p = 0.002$ and $p = 0.003$, for intake, mothers' and observers' ratings, respectively) with infants in Dijon consuming less peas and rated as liking peas less. This is probably because, as noted above, the pea purée offered to infants in Dijon was thicker, more bitter and less sweet (Supplementary data).

Discussion

This study confirms and extends earlier observations on effects of type of milk feeding and experience with vegetable variety at weaning on subsequent acceptance of new foods. It confirmed the short-term effects of breastfeeding[2] and experience with daily changes of vegetables early in weaning[3] on increase in intake of new foods over the next

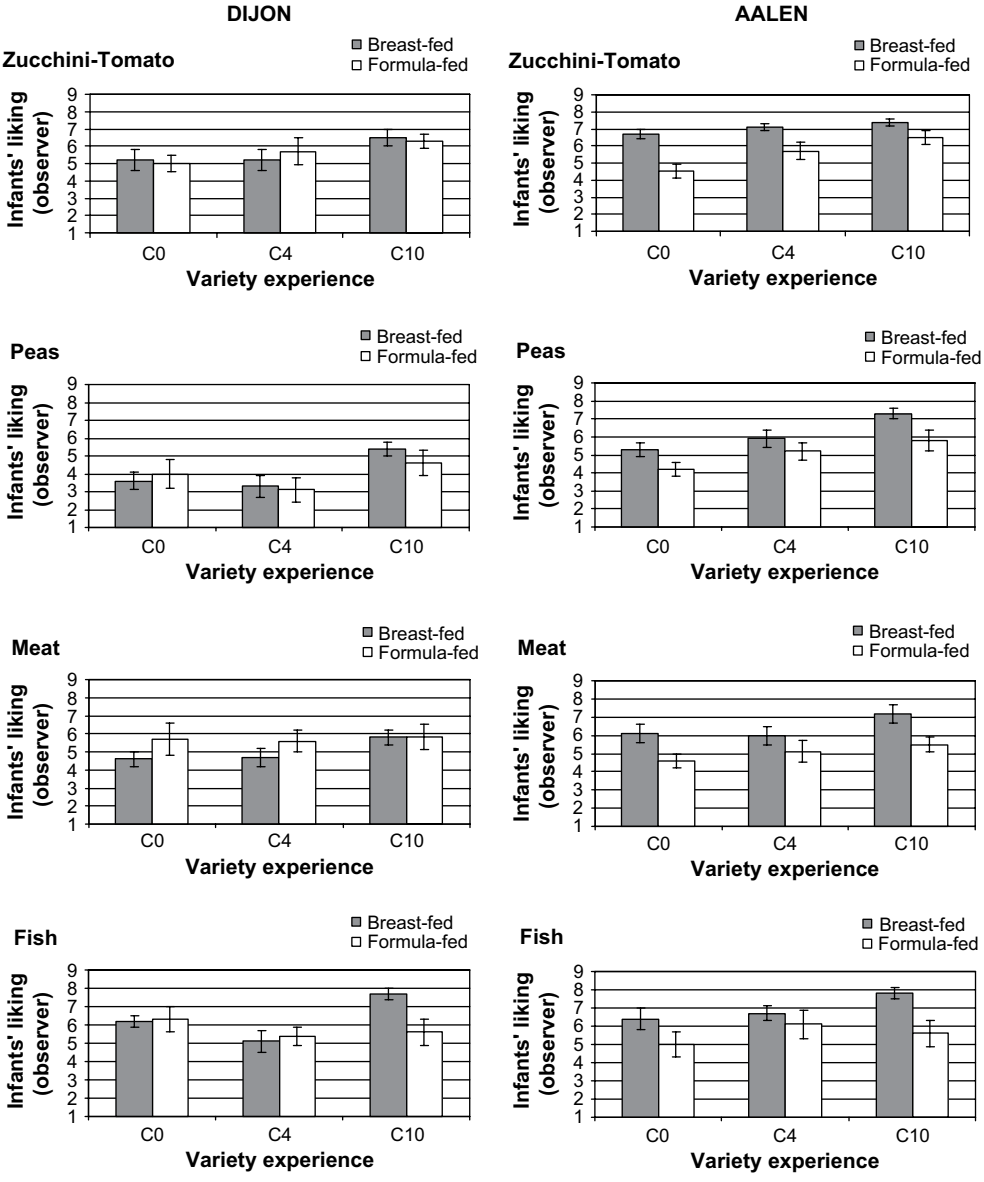

Figure 5 Effect of milk feeding (breast or formula) and experience with vegetable changes early in weaning on liking ratings given by observers (mean ± SEM) for the two new vegetables, meat and fish in Dijon and Aalen. C0 (0 changes) = carrot purée for 9 days, C4 (4 changes) = low variety group with 3 different purées (artichoke, pumpkin and green beans) each given for 3 consecutive days, and C10 (10 changes) = high variety group with the same 3 purées, but with a change every day.

few days and showed that some of these effects were still detectable up to 2 months later.

For intake, the breastfeeding effect seemed to attenuate with time (it was no longer significant for meat and fish, presented later) while that of experience with variety did not. However as, for obvious reasons, it was not possible to introduce meat and fish earlier and before vegetables, the time effect is confounded with the food type, thus we cannot definitely conclude that there was an evolution of the breastfeeding effect with time. Closer examination of the results showed that the *combination* of breastfeeding and high variety experience was most effective in increasing intake of new foods. This effect was observed for all 4 foods, so persisted for at least 2 months. We had previously observed[1] that, at the start of vegetable feeding, many mothers in Dijon changed the vegetable they gave every day, while in Aalen many gave the same vegetable for 1–2 weeks. We can now conclude that these differences in weaning practice are likely to have practical consequences for acceptance of new foods.

Offering 3 vegetables for 3 consecutive days each did not significantly increase intake of new foods relative to no changes so this regimen was not efficient in increasing acceptance of new foods. This suggests that perhaps it is the number of daily changes rather than the number of different foods that leads to increase in acceptance of new foods.

We explored the possibility that differences between experimental groups in the length of the period between vegetable and meat introduction and/or the variety experienced during this time might contribute to the pattern of the results for meat and fish. In each region, however, all measures of variety experience were similar across groups, so this cannot be the explanation for the higher intake noted in C10 breast-fed infants.

One limitation of this study is that although mothers were ''blind'' to the study hypotheses, they could not be ''blind'' to the treatment, so influences other than variety regimens may have influenced infant food acceptance. A second is that breastfeeding cannot be randomized. However, there were no differences in food neophobia, variety seeking or anxiety scores between mothers who breast-fed and those who did not. Finally, one advantage in our study was that all the vegetable purées given during Phase A at home were iso-caloric so differences in intake among the 3 variety groups were not contaminated by possible effects linked to energy density.

Conclusion

This study shows that both breastfeeding and daily changes in vegetables offered early in weaning, especially in combination, can facilitate acceptance of new foods for at least up to 2 months. The interventions used correspond to differences in milk feeding and weaning patterns already observed,[1] suggesting that the results have practical consequences for new food acceptance. On-going follow-up studies will establish if these effects are longer-lasting.

Acknowledgements

We would like to thank the mothers and infants who took part in this study, the paediatricians, Dr. Gerlinde Grill and Dr. Vincent Boggio, who helped recruit them, and technicians Maria Manz, Paula Baumann, Emilie Szleper, Valérie Feyen and Julie Millery who helped collecting the data. We also would like to thank Nestlé PTC Singen for supplying the baby foods and carrying out the sensory profiling of them and Nestlé Nutrition for funding the study.

Contributors

Each author has participated sufficiently, intellectually or practically, in the work to take public responsibility for the content of the article, including the conception, design and conduct of the experiment and for data interpretation (authorship). A.S.M. conceived and designed the study, collected data, performed the data analysis, and wrote the manuscript. All other co-authors helped to design the study, perform data analyses and have read and commented the manuscript thoroughly.

Disclosure statement

A.S.M. and P.D.L. are Nestec employees and S.N.I. and B.S. were in receipt of funding from Nestlé Nutrition. The study sponsors, however, did not influence the study design, collection, analysis, interpretation of data, or the writing of the manuscript.

Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.clnu.2008.08.002.

References

1. Maier AS, Chabanet C, Schaal B, Leathwood P, Issanchou S. Food-related sensory experience from birth through weaning: contrasted patterns in 2 nearby European regions. *Appetite* 2007;**49**(2):429–40.
2. Sullivan SA, Birch LL. Infant dietary experience and acceptance of solid foods. *Pediatrics* 1994;**93**:271–7.
3. Gerrish CJ, Mennella JA. Flavor variety enhances food acceptance in formula-fed infants. *American Journal of Clinical Nutrition* 2001;**73**:1080–5.
4. Jarosh W, Phelan G, Dwyer JT, Ziegler PJ, Hendricks K. Menus for infants and toddlers to explore the dietary world. *Nutrition Today* 2006;**41**(4):144–52.
5. Pliner P, Hobden K. Development of a scale to measure the trait of food neophobia in humans. *Appetite* 1992;**19**(2):105–20.
6. van Trijp HCM, Steenkamp J-BEM. Consumers' variety seeking tendency with respect to foods: measurement and managerial implications. *European Review of Agricultural Economics*. 1992; **19**(2):181–95.
7. Spielberger CD. *Inventaire d'anxiété état-trait, forme Y*. Paris: Les Editions du Centre de Psychologie Appliquée; 1993.
8. Bertrais S, Larroque B, Bouvier-Colle MH, Kaminski M. Tempérament des nourrissons âgés de 6 à 9 mois: validation de la version française de l'Infant Characteristics Questionnaire et facteurs associés à la mesure. *Revue d'Epidémiologie et de Santé Publique*. 1999;**47**(3):263–77.