

Yield and nutrient content of milk in eight women breast-feeding twins and one woman breast-feeding triplets

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1. The milk yield of eight mothers each breast-feeding twins was determined by test weighing the mothers. Milk yield was determined at 2, 3, 6, 9, and 12 months post partum; however, only one mother was studied at all these times.
2. At 6 months post partum the milk yield for individual breasts of three mothers fully breast-feeding and four mothers partially breast-feeding their infants ranged from 0.84 to 2.16 kg/24 h and 0.42 to 1.39 kg/24 h respectively. The average frequency of breast-feeding for the mothers studied at 6 months post partum was 15.4 feeds/24 h.
3. The milk yield of one mother fully breast-feeding 2.5-month-old triplets was 3.08 kg/24 h and the infants were fed twenty-seven times in 24 h.
4. The concentration of lactose, protein and mixed fat in the milk from individual breasts of mothers fully breast-feeding their infants ranged from 65.6 to 82.2, 7.8 to 15.7 and 16.7 to 46.2 g/l respectively. For the three mothers partially breast-feeding 12-month-old infants the values ranged from 54.8 to 71.8, 14.2 to 19.9 and 4.7 to 40.5 g/l respectively.
5. At 6 and 12 months of age, the proportion of the total energy intake of the infants which was derived from breast milk ranged from 64 to 100% and 6 to 13% respectively.
6. It is concluded that the maximum potential milk yield for women may be higher than the often quoted value of 700–800 ml/24 h.

Generally, volumes of breast milk between 700 and 800 ml/24 h have become accepted as the maximum milk yield considered possible from an average healthy and well-nourished mother (Wallgren, 1944–45; Lonnerdahl *et al.* 1976; Jelliffe & Jelliffe, 1978*a, b*; Whitehead, 1983). Further, it has been concluded from these values and from infant growth indices that this milk yield would provide adequate nutrition for the infant for the first 2–3 months of life (Waterlow & Thompson, 1979; Whitehead *et al.* 1980; Rowland *et al.* 1981). Western Australian mothers breast-feeding their infants on demand have been reported to produce greater than 1100 ml/24 h from 2 weeks post partum (Rattigan *et al.* 1981; Saint *et al.* 1984). This milk yield would be sufficient to meet the nutritional needs of the infants for more than 8 months (Rowland *et al.* 1981). Some earlier studies have reported high milk yields and support the Western Australian findings (Macy *et al.* 1930; Nims *et al.* 1932; Kaucher *et al.* 1945; Roderuck *et al.* 1946). The highest yields were reported by Macy *et al.* (1930) for women expressing their breast milk for milk banks, in addition to breast-feeding their own infant. These workers concluded that milk yield adjusts to demand and large quantities of breast milk may be produced if the demand is great enough (Macy *et al.* 1930, 1945; Macy, 1949).

Although studies in animals have shown that the metabolic capacity of the mammary gland increases to meet the nutritional needs of more than one offspring (Hayden *et al.* 1979; Sadleir, 1980), Deem (1931) is the only available study on milk yield following a multiple birth in women. The study recorded a milk yield of 2355 ml/24 h for one woman breast-feeding twins.

The current study was conducted to determine the yield and composition of breast milk

Table 1. *Details of the mothers studied*

Mother	Age of mother (years)	Delivery	Gravida	Parity	Sex of infants	Preferred breast*	Maternal wt (kg)		Lactational amenorrhoea (months post partum)
							Initial	Final	
T ₁	26	Spontaneous vaginal	2	4	♂♂	R/L	62.3	61.4	12
T ₂	32	Caesarian	2	3	♂♂	R/L	74.2	74.9	12
T ₃	27	Caesarian	1	2	♂♂	R/L	54.0	47.4	13
T ₄	27	Induction vaginal	1	2	♀♂	R/L	58.2	—	6
T ₅	33	Caesarian	2	3	♀♀	R/L	51.5	55.7	13
T ₆	30	Caesarian	3	4	♀♀	R/L	60.0	58.2	13
T ₇	33	Caesarian	1	2	♂♂	R/L	52.2	53.5	9
T ₈	33	Caesarian	1	2	♀♀	N/N	80.1	77.9	9
Tr	30	Caesarian	2	4	♀♂♀	N/N/N	67.3	—	7

* R, Infant suckled exclusively on the right breast; L, infant suckled exclusively on the left breast; N, infant suckled at each breast with no preference for right or left breasts.

in eight Western Australian women who gave birth to twins and one woman who gave birth to triplets.

EXPERIMENTAL

Mothers

Eight healthy women (T₁–T₈) who were breast-feeding twins and one woman (Tr) breast-feeding triplets on demand provided informed consent to participate in the study. Details of the mothers are shown in Table 1. Mothers T₁ and T₃ were studied at both 6 and 9 months post partum and T₂ was studied at 6, 9 and 12 months post partum. Mother T₄ was studied at 6 months post partum and T₆ was studied at 3 and 6 months post partum. Mother T₇ was studied at 3, 6, 9 and 12 months post partum and T₅ was studied at 2, 3, 6, 9 and 12 months post partum. Mother T₈ was only studied at 2 and 3 months post partum.

The pattern of breast-feeding of seven sets of twins was such that each twin only fed from a preferred breast. The infants of mother T₈ each sucked the right and then the left breasts at each feed. All infants studied at 2 and 3 months of age were fully breast-fed and the infants of mothers T₃, T₅ and T₆ were fully breast-fed at 6 months of age. Mother T₄ partially breast-fed her infants (they were suckled at the breast and then offered a supplementary feed of formula from a bottle), whereas all other partially breast-fed infants were supplemented with solids but were not given formula from a bottle. The mother fully breast-feeding triplets (Tr) was studied at 2.5 months post partum. The triplets were fully breast-fed to 4 months post partum and partially breast fed to 4.5 months post partum. This mother normally breast-fed her infants (Tr₁, Tr₂ and Tr₃) in rotation; two infants (Tr₁ and Tr₂) were suckled simultaneously on the right and left breast respectively, and the third infant (Tr₃) suckled both the right and left breasts. At the next feed two infants (Tr₂ and Tr₃) were suckled simultaneously at the right and left breasts respectively, and Tr₁ was then suckled at both the right and left breast. This step rotation of each infant was recorded by the mother to ensure that each infant was given an equal opportunity at the breast.

Milk yield

The milk yields of the right breast and left breast respectively, of mothers T₁–T₈ were determined by measuring the decrease in the weight of the mother after each infant was

suckled at the preferred breast using the method of Rattigan *et al.* (1981). The mother's weight was recorded with a beam balance (type 3550-AAA balance; Avery Australia Limited) before and after breast-feeding. Mothers performed the test weighings in their home during two separate 24 h periods at each stage of lactation.

Determination of milk yield from individual breasts was not possible for the mother breast-feeding triplets, since one or other of the three infants fed from both breasts at each feeding period. Therefore, for the measurement of 24 h milk yield, each infant was breast-fed independently and the mother weighed before breast-feeding and then after each infant had been suckled at the breast.

Milk composition

Samples of breast milk (about 0.5 ml) were collected by manual expression from the right and left breasts before (fore sample) and immediately after (hind sample) breast-feeds during the 24 h periods that the mothers performed the test weighing. Mothers T₃, T₅, T₆ and T₇ collected fore and hind samples from the right and left breasts at each feed for the 24 h period studied. Mothers T₁, T₂, T₄, T₈ and Tr collected breast milk samples from both breasts at twelve-hourly intervals.

The concentration of lactose in the milk samples was determined as described previously (Hartmann & Kulski, 1978). The total protein content in the milk samples was determined by a modification of the Lowry assay described by Healy *et al.* (1980). Total triglyceride concentration of the fore- and hind-milk samples was analysed using a modification of the method of Martin (1975). Estimation of the average concentration of fat in the milk (mixed milk) was calculated using the following equation:

$$Y = 0.61X_1 + 0.58X_2 - 0.273,$$

where X_1 is the triglyceride concentration in fore milk, X_2 is the triglyceride concentration in hind milk and Y is the triglyceride concentration in mixed milk (see Hartmann & Saint, 1984).

The energy content of breast milk was calculated by assuming the energy content of milk lactose, protein and fat to be 17.4, 23.4 and 39 kJ/g respectively (Maynard & Loosli, 1956).

RESULTS

Twins

Milk yield. The milk yields for the right and left breasts for mothers T₅ and T₇ and mothers T₁, T₂, T₃, T₄, T₆, and T₈ are shown in Fig. 1 and Table 2 respectively. The milk yield for individual breasts for mothers T₅ and T₇ ranged from 0.84 to 1.50 kg/24 h from 2 to 6 months of lactation and then declined to 0.12–0.31 kg/24 h by 12 months of lactation (Fig. 1). Milk yields for individual breasts for the three mothers who were fully breast-feeding at 6 months of lactation, and for the other four mothers who were partially breast-feeding their infants at this time, ranged from 0.84 to 2.16 kg/24 h and 0.42 to 1.39 kg/24 h respectively.

Feeding frequency. The frequency of breast-feeding for the right and left breasts of mothers T₅ and T₇ and mothers T₁, T₂, T₃, T₄, T₆, and T₈ are shown in Fig. 1 and Table 2 respectively. Feeding frequency for each breast ranged from 6 to 12 feeds/24 h for mothers studied during the first 6 months post partum but dropped to 1–3 feeds/24 h for the three mothers studied at 12 months post partum. The average feeding frequency for the seven mothers (right plus left breasts) studied at 6 months of lactation was 15.4 feeds/24 h and their average total milk yield was 2.25 kg/24 h. However, there was no relation between feeding frequency and milk yield for mothers at this stage of lactation (Table 2).

Milk composition. The concentrations of lactose, total protein and mixed fat for the right

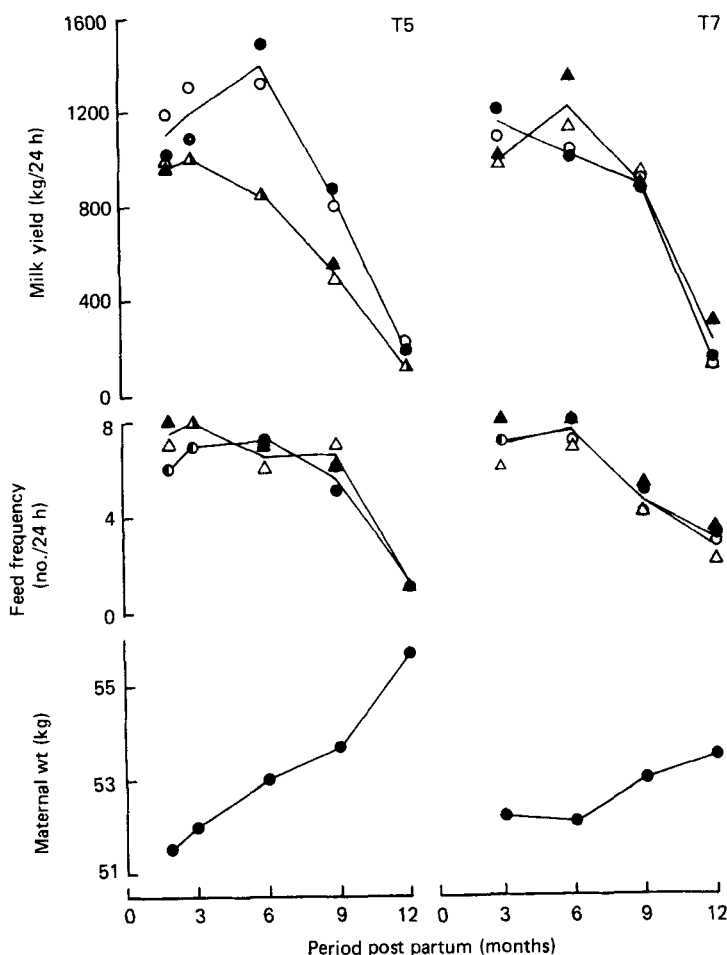


Fig. 1. Progressive changes in the milk yield (kg/24 h), frequency of breast-feeding (no./24 h) and body-weight (kg) of mothers T_5 and T_7 . The milk yield and frequency of breast-feeding was determined for two separate 24 h periods on the right (\bullet , \circ) and left (\blacktriangle , \triangle) breast at 2, 3, 6, 9 and 12 months post partum for T_5 and at 3, 6, 9 and 12 months post partum for T_7 .

and left breasts of the mothers T_5 and T_7 and mothers T_1 , T_2 , T_3 , T_4 , T_6 , and T_8 are shown in Fig. 2 and Table 2 respectively. The concentration of lactose, protein and mixed fat in milk from individual breasts of mothers fully breast-feeding their infants ranged from 65.6 to 82.2, 7.8 to 15.7 and 16.7 to 46.2 g/l respectively. For the three mothers breast-feeding 12-month-old infants the concentration of lactose, protein and mixed fat in milk from individual breasts ranged from 54.8 to 71.8, 14.2 to 19.9, and 4.7 to 40.5 g/l respectively (Fig. 2 and Table 2).

Energy intake from breast milk. The percentage of the energy intake which was derived from breast milk for infants between 6 and 12 months of age is presented in Table 3. Breast milk was the only source of energy for all infants studied at 2 and 3 months of age and for the infants of mothers T_3 , T_5 , and T_6 at 6 months of age. The percentage of the energy intake which was derived from breast milk for the three sets of twins studied at both 6 and 12 months of age declined from 64–100 to 6–13 respectively (Table 3).

Infant weight development. The weight of the infants from birth to 12 months post partum

Table 2. *The stage of lactation, feeding frequency, milk yield and concentration of lactose, protein and mixed fat of mothers* T_1, T_2, T_3, T_4, T_6 and T_8

(The values presented for lactose, protein and fat are the means and standard deviations for all milk samples collected for the two 24 h periods at each stage of lactation)

Mother	Period post partum (months)	Feeding frequency (no./24 h)		Milk yield (kg/24 h)		Lactose (g/l)				Protein (g/l)				Mixed fat (g/l)			
		Right		Left		Right		Left		Right		Left		Right		Left	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T_1	6	10, 10	10, 9	1-20, 1-39	1-03, 1-07	72.4	2.4	73.2	3.6	8.8	0.2	8.7	0.4	9.2	3.8	11.8	2.6
	9	11, 9	12, 8	1-42, 0-96	1-41, 0-96												
T_2	6	10, 8	10, 8	1-30, 0-98	0-83, 0-77	73.0	0.5	72.2	2.5	11.4	2.0	13.1	0.9	10.8	8.3	15.8	4.3
	9	11, 8	11, 8	1-16, 1-47	0-76, 1-06	75.8	2.0	76.9	0.7	12.3	0.4	14.1	1.7	16.3	1.9	16.6	2.8
T_3	12	1, 1	1, 1	0-4, 0-25	0-23, 0-18	71.8	9.0	68.0	0.8	16.0	2.2	17.7	1.1	12.1	10.0	4.7	1.9
	6	6, 6	6, 6	1-04, 0-89	0-86, 0-93	69.2	4.9	77.5	7.0	8.4	0.3	10.0	1.9	23.5	3.1	22.3	7.2
T_4	9	5, 7	5, 5	0-69, 0-99	0-76, 0-77	77.3	7.6	76.6	11.6	8.0	0.9	7.8	1.3	16.7	2.6	22.3	2.9
	6	8	8	0.42	0.47	59.7	8.0	67.7	9.7	10.7	0.8	13.6	3.4	22.4	7.6	31.4	6.6
T_6	3	7, 8	8, 8	1-62, 1-84	1-64, 1-78	76.1	4.0	75.0	3.2	11.2	0.8	11.0	0.8	18.2	2.2	19.6	4.4
	6	7, 7	7, 7	2-13, 2-04	2-08, 2-16	72.0	1.4	70.3	2.6	12.0	1.3	12.3	1.4	20.9	5.3	26.3	7.8
T_8	2	6, 6	6, 6	1-15, 1-02	1-13, 1-14	71.0	7.2	82.2	2.6	13.4	1.8	15.7	0.4	31.9	7.0	28.5	7.0
	3	6, 5	6, 5	1-08, 1-12	1-16, 1-19	78.9	5.6	78.8	7.8	12.9	1.9	13.2	2.4	43.8	17.5	46.2	17.3

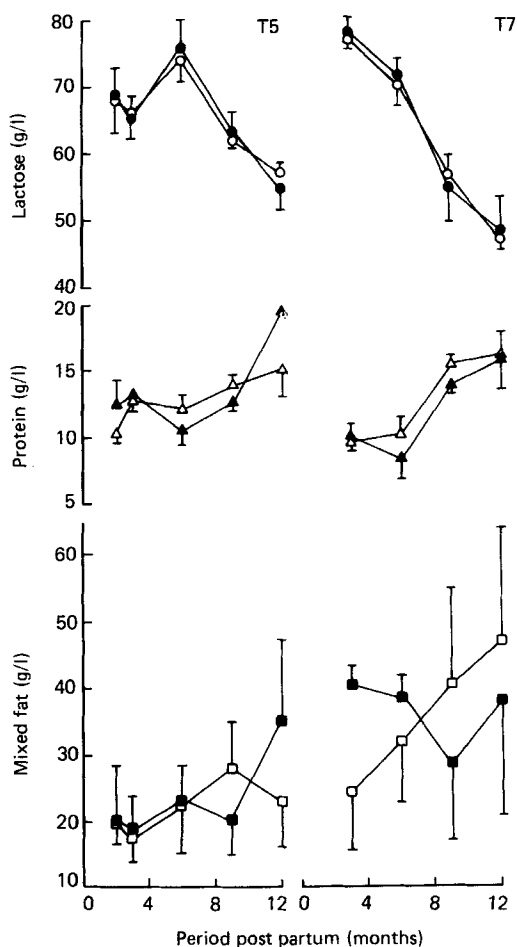


Fig. 2. Changes in the concentrations (g/l) of lactose, protein and mixed fat for the right (●, ▲, ■) and left (○, △, □) breasts for mothers T₅ and T₇. The values presented are the means and standard deviations, represented by vertical bars, for all milk samples collected for the two 24 h periods at 2, 3, 6, 9 and 12 months post partum for T₅ and at 3, 6, 9 and 12 months post partum for T₇.

Table 3. The percentage of energy intake derived from breast-milk for infants suckled at the right and left breasts at 6, 9 and 12 months post partum

Period post partum (months)...	Right breast			Left breast		
	6	9	12	6	9	12
T ₁	50	60	—	46	59	—
T ₂	66	51	11	61	47	6
T ₃	100	31	—	100	33	—
T ₄	43	—	—	42	—	—
T ₅	100	32	13	100	28	9
T ₆	100	—	—	100	—	—
T ₇	64	52	9	76	60	14

Milk yield following multiple birth

55

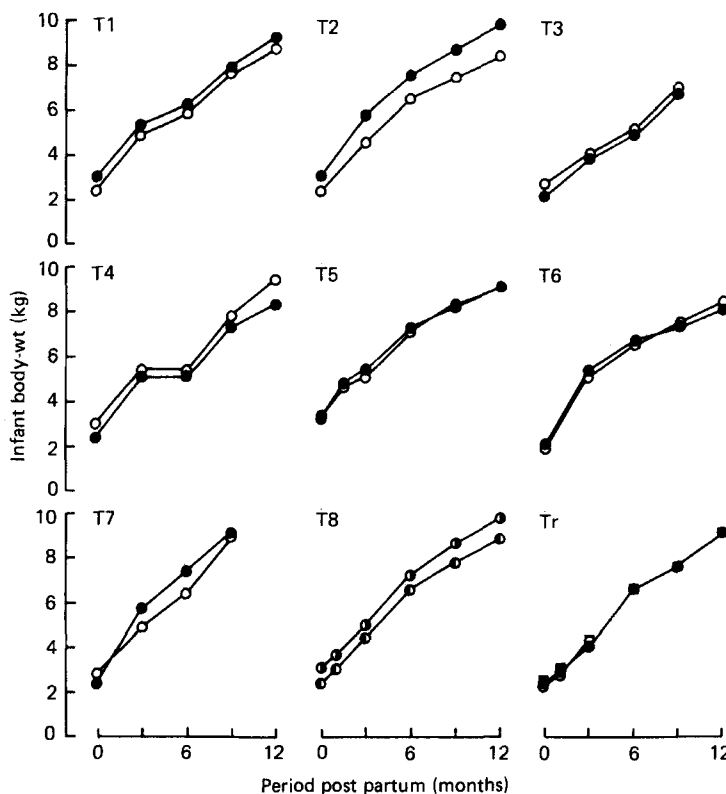


Fig. 3. The nude weight (kg) of the infants suckled exclusively at the right (●) and left (○) breasts respectively, of mothers T₁, T₂, T₃, T₄, T₅, T₆, and T₇, and those of infants T₈ and Tr suckled at either breast, from birth to 12 months of age.

is shown in Fig. 3. The mean birth weights of infants suckled at the right and left breast were 2.75 (SD 0.43) and 2.69 (SD 0.42) kg respectively. All but six of the infants were below the 10th percentile for mass at birth (NH & MRC, 1975). By 3 months post partum all but four infants were below the 10th percentile for mass. The mean body-weight for the infants fully breast-fed to 6 months of age was 6.36 (SD 0.94) kg, whereas that for infants partially breast-fed at 6 months of age was 6.32 (SD 0.88) kg.

Maternal weight. Maternal weight was recorded on each occasion the mother participated in the study. Weight of each mother at commencement of the study and again at termination of the study are shown in Table 1 and the progressive changes in weight for mothers T₅ and T₇ is shown in Fig. 1. Seven mothers participated in the study on more than one occasion and of these women, three (T₂, T₅ and T₇) experienced weight gain during their participation in the study. Four mothers (T₁, T₃, T₆ and T₈) experienced an average weight loss of 1.15 kg/month during their lactation.

Triplets

The volume of breast milk consumed at each feed over a 24 h period by each of the infants at 2.5 months post partum is shown in Fig. 4. Mother Tr produced a total of 3.08 kg breast milk and each infant was fed nine times over the 24 h period. The largest volume of breast milk consumed by each infant occurred between 08.00 and 12.00 hours. The mean concentrations (g/l) of lactose, total protein and mixed fat in the mother's breast milk were:

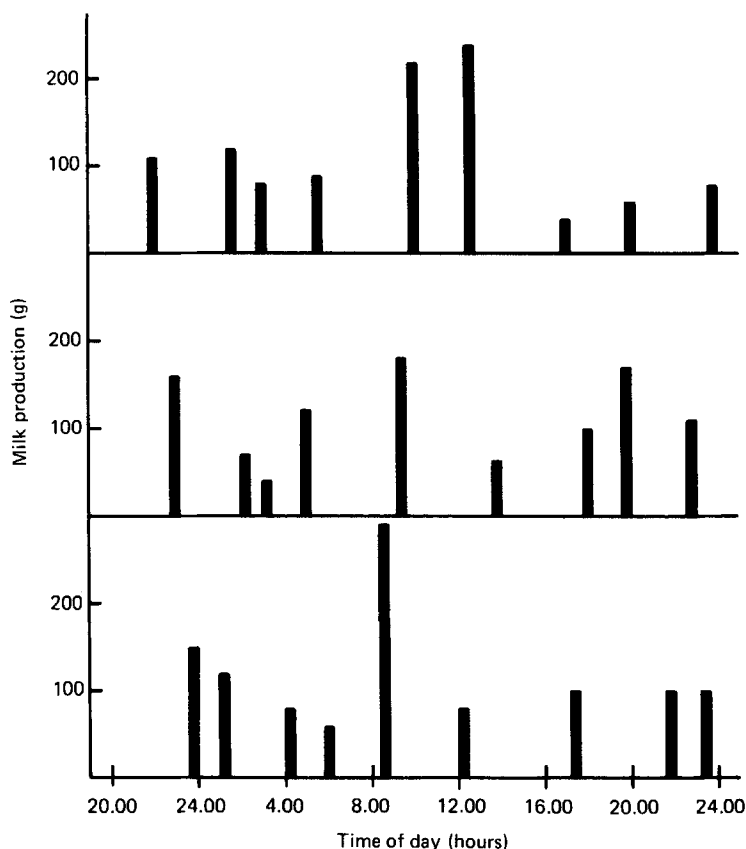


Fig. 4. The intake of breast milk (g) and frequency of breast feeding of triplets Tr₁, Tr₂ and Tr₃ breast-fed on demand over a 24 h period at 2.5 months of age.

83.6 (SD 6.7) right breast and 85.1 (SD 7.6) left breast, 9.1 (SD 1.6) right breast and 9.1 (SD 1.2) left breast, 16.5 (SD 6.1) right breast and 15.4 (SD 6.6) left breast respectively.

DISCUSSION

The number of Western Australian women choosing to breast-feed their infants has increased over the past 10 years (Hartmann *et al.* 1985) and this has led to an increase in the number of women breast-feeding infants following a multiple birth. Mothers who deliver twins and in some cases triplets are breast-feeding and appear to be successfully meeting the nutritional needs of their infants for several months. Despite obvious difficulties in conducting longitudinal lactation studies with mothers caring for more than one baby, eight mothers breast-feeding twins and one mother breast-feeding triplets were recruited for the study and participated for varying periods during their lactation.

The milk yield of the mothers participating in the study was determined by measuring the decrease in the weight of the mothers at each breast feed over a period of 24 h with a beam balance (Rattigan *et al.* 1981). Higher milk yields are obtained using this method compared with test weighing the infant (Saint *et al.* 1984). This difference is due to sweating and insensible water losses which result in the overestimation of milk yield by about 15%

when the mother was test weighed, and the underestimation of milk yield by about 10% when the infant was test weighed (P. G. Arthur and P. E. Hartmann, unpublished observations). However, it was not possible to correct accurately the present measurements of milk yield because neither the evaporative weight loss of the mothers nor the time-interval between weighings was measured.

Compared with the milk yields reported previously for Western Australian mothers breast-feeding one infant (Rattigan *et al.* 1981; Saint *et al.* 1984), all but one of the mothers breast-feeding twins produced almost twice as much milk daily when studied during the first 9 months post partum (Table 2 and Fig. 1). It is probable that the increased milk yield in the mothers breast-feeding twins was due to the increased sucking stimulus and milk withdrawal (Table 2 and Fig. 1) rather than the possible promotion of breast growth and development by the twin conceptus during pregnancy. Prosser *et al.* (1984) observed a mother who was tandem breast-feeding (i.e. the mother breast-fed her infant throughout pregnancy and then breast-fed both the older and the newborn infant after delivery). This mother produced in excess of 2.0 kg breast milk/d. It was concluded that the additional milk yield resulted from the increase in sucking frequency and milk withdrawal. In this connection, mothers breast-feeding twins on each breast simultaneously were found to have double the prolactin response to sucking compared with mothers breast-feeding one infant (Tyson *et al.* 1976). However, there is an equivocal relation between the concentration of prolactin in blood and milk yield in women (Cowie *et al.* 1980).

Deem (1931) reported similar milk yields to those observed in the current study (Table 2 and Fig. 1) for a New Zealand mother breast-feeding twins, as did Prosser *et al.* (1984) for a mother tandem breast-feeding. Furthermore, Macy *et al.* (1930) studied three women who breast-fed their babies and expressed surplus milk for a milk bank and found that they produced between 1.5 and 3.0 litres/24 h. In this connection it is of interest that the woman breast-feeding 2.5-month-old triplets produced approximately 3.0 kg/24 h and fed twenty-seven times in 24 h (Fig. 4). Together these findings indicate that the maximum potential milk yield for women may be higher than the often quoted value of 700–800 ml/d (see Whitehead, 1983).

The concentration of lactose in milk samples of the mothers studied (Table 2 and Fig. 2) was generally higher than values previously reported in the literature (Hartmann *et al.* 1985). In particular, the mother breast-feeding triplets had a mean concentration of lactose in breast milk of 83.6 (SD 6.7) and 85.1 (SD 7.6) g/l for her right and left breasts respectively. Although a close relation between milk yield and lactose has been reported in both women (Saint *et al.* 1984) and animals (Hartmann, 1973) during the initiation of lactation, such a relation has not been noted during established lactation.

The energy intake of the twins was similar to values reported by Rattigan *et al.* (1981) for singletons of a similar age. Although the birth weight of only six of the infants was above 2.8 kg (the 10th percentile for mass), by 12 months of age there was evidence of 'catch-up' growth and twelve of the infants studied (Fig. 3) had a body-weight greater than 8.5 kg (the 10th percentile for mass at 12 months post partum). Preliminary studies by Jelliffe (1976) on a group of twins in California fully breast-fed for 3–6 months have shown good rates of growth, indicating that these mothers were adequately meeting the nutritional requirements of their sucking infants. This conclusion has been confirmed by the present study (Fig. 3).

The present findings demonstrate that women are capable of producing enough breast milk to nourish twins. Elucidation of the means by which the mammary gland makes the biochemical adjustments necessary for the mother to meet the nutritional needs of more than one infant is of practical significance, particularly for the poorer mothers in developing nations where adequate milk yield is vital for the survival of their single infants.

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