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HOME-MODIFIED ANIMAL MILK FOR REPLACEMENT FEEDING: IS IT FEASIBLE AND SAFE ?

World Health Organization

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Introduction

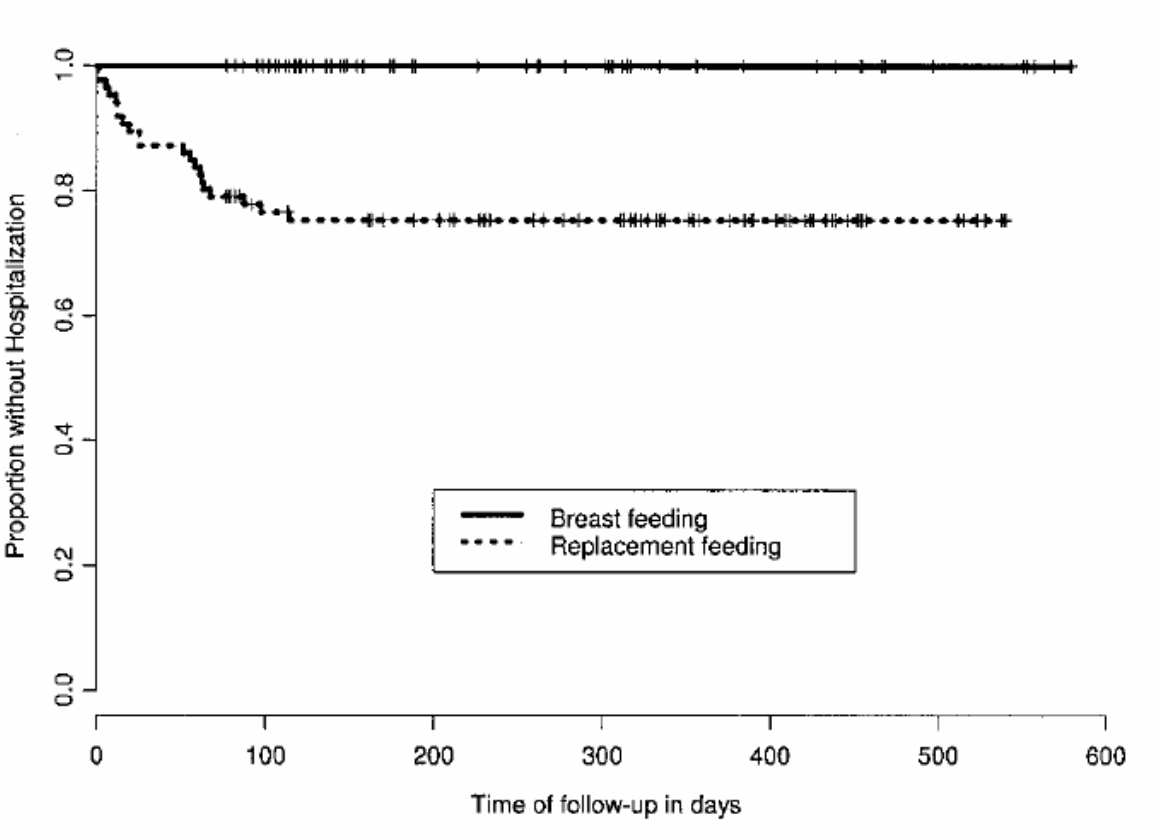
According to current UN recommendations, infants should be exclusively breastfed for the first six months of life, and thereafter should receive appropriate complementary feeding with continued breastfeeding up to two years of age or beyond.[1] However, there are a number of infants who will not be able to enjoy the benefits of breastfeeding in the early months of life. A group that calls for particular attention is the infants of mothers who are known to be HIV-positive. To reduce the risk of transmission, it is recommended that when replacement feeding is acceptable, feasible, affordable, sustainable and safe (AFASS), mothers should avoid breastfeeding from birth. Otherwise, they should breastfeed exclusively and make the transition to exclusive replacement feeding as soon as alternative feeding options become AFASS[2]. Other circumstances that may prevent a child from being breastfed include death or severe illness in the mother, or inability or lack of desire by the mother to breastfeed.

UN guidelines on HIV and infant feeding from birth to six months for infants of HIV-positive mothers describe possible options for replacement feeding[3]. Commercial infant formula and home-modified animal milk are both presented. According to these guidelines, home-modified animal milk can be prepared either from fresh milk or full-cream milk powder and evaporated milk. On the other hand, unmodified animal milk, skimmed and sweetened condensed milk, fruit juices, sugar water and dilute cereal gruel are presented as unsuitable replacement foods.

Current guidelines express concern regarding the safety of preparation for both commercial infant formula and home-modified animal milk. Additional concerns about health effects, use of micronutrient supplements and the safety aspects of storage and feeding of home-modified animal milk are also mentioned. However, there is no clear recommendation on how to choose between the two options which might be seen as broadly equivalent. In the WHO/UNAIDS/UNICEF training course on HIV and infant feeding,[4] first published in 2000, home-modified animal milk is even presented before commercial infant formula, something that might imply that it is a preferable option. In the new integrated course on infant feeding being finalized, infant formula is presented before home-modified animal milk.

Since current guidelines and the HIV and infant feeding training manual were drafted, additional concerns were raised on the suitability of home-modified animal milk for replacement feeding for children aged less than six months. A study from India showed that children who received replacement feeding, predominantly cow or buffalo home-modified milk, had a highly increased rate of hospital admission, mainly due to gastroenteritis with dehydration (Figure).[5] Another study from South Africa found that appropriate micronutrients for this purpose were not available in the local market, and noted the lack of essential fatty acids in current recipes.[6]

Figure



Kaplan-Meier estimate of the time to first hospitalization by infant-feeding practice for infants born to HIV-infected mothers in Pune, India. Most children had replacement feeding made from home-modified animal milk. From: Phadke MA, Gadgil B, Bharucha KE, Shrotri AN, Sastry J, Gupte NA, Brookmeyer R, Paranjape RS, Bulakh PM, Pisal H, Suryavanshi N, Shankar AV, Propper L, Joshi PL, Bollinger RC. Replacement-fed infants born to HIV-infected mothers in India have a high early postpartum rate of hospitalization. J Nutr. 2003; 133: 3153-7.

An additional concern is that, to our knowledge, no experience of successful large-scale use of home-modified animal milk in programme settings has been documented since the guidelines were released.

The purpose of this paper is to examine the nutritional aspects of feeding home-modified milk. This paper focuses only on non-breastfed children aged 0 to 6 months with no access to infant formula. Feeding older non-breastfed infants is described in another WHO document.[7] Other problems, including the risk of dilution error when modifying the milk, the risk of bacterial contamination, and the risk that it will cause occult bleeding in the gut if not adequately boiled are acknowledged, but will not be discussed here.

Current recipe

In the WHO/ UNAIDS/ UNICEF training course on HIV and infant feeding, the recipes shown in Table 1 are proposed to modify fresh cow milk to make it suitable for

replacement feeding. The same recipe can be applied to goat or camel milk whereas a different dilution should be used for buffalo or sheep milk.

Table 1 Recipes for home-prepared infant formula with fresh cow milk

Quantity of cow milk (ml)	Added water (ml)	Added sugar (g)	Amount of prepared formula (ml)
40	20	4	60
60	30	6	90
80	40	8	120
100	50	10	150

If powdered full-cream milk is used instead of fresh milk, it is advised to reconstitute the whole milk according to the label and then to modify the reconstituted milk using the same recipe as for fresh milk. Mineral and vitamins supplements should be given with these home-prepared formulas.

Essential fatty acid content of the current recipe

The essential fatty acid composition per 100 kcal of the modified animal milk recipe, based on available data of essential fatty acid composition of cow milk,[8] is compared with current recommendations made by various committees on infant feeding[9,10,11] in Table 2.

Table 2 Comparison of the fatty acid content of the current home-prepared formula with international recommendations

		International recommendations		
	Home- prepared formula	FAO[a]	Codex	European Union
(n-3) mg/100 kcal	54	50	-	50
(n-6) mg/100 kcal	83	600	300	(n-3) * 5

These calculations show that the (n-6) essential fatty acid content of the present home-modified formula is below current recommendations. Children fed with this formula are likely to develop essential fatty acid deficiency, with dermatitis, growth retardation and impaired cognitive development as possible consequences.[6]

[a] The FAO / WHO recommendations are expressed per Kg body weight. It was assumed to be equivalent to the amount needed per 100 Kcal as energy requirements of young infants is close to 100 Kcal / Kg.

Possible options for improving the essential fatty acid content of home-modified formula

A simple option to improve the essential fatty acid content of the home-made formula is to add vegetable oil. Table 3 shows the (n-3) and (n-6) essential fatty acid content of different forms of oil.[4,12]

Table 3 Essential fatty acids of different vegetable oils, in % of total weight

	(n-6) (%)	(n-3) (%)	(n-6) / (n-3)
Corn	58	0	NA
Sunflower	65.7	0	NA
Rapeseed	22.1	11.1	2
Soya	34.9	2.6	13.4
Groundnut	38	0	NA

Of the different oils examined, soy oil has the double advantage of having a high essential fatty acid content and a good (n-6):(n-3) ratio (13.4). According to FAO recommendations, this ratio should be between 5 and 10 for all age groups. The European Directive regulates that this ratio range between 5 and 15 for infant formula. Hence, adding soy oil is the preferred method for increasing the essential fatty acid composition of home-modified animal milk. In the absence of soy oil, other oils rich in (n-6) fatty acids could be used.

Table 4 summarizes the quantity of different vegetable oils that would be needed to provide 300 mg of (n-6) fatty acids, the amount recommended per 100 kcal of infant formula in the *Codex Alimentarius*. Quantities needed daily for different body weight are also presented, assuming that energy requirements are equivalent to 100 kcal/kg/day.

Table 4 Quantity of oil (ml) needed daily to provide 300 mg of (n-6) fatty acids per 100 kcal/day

	Per 100 kcal	For different body weights (kg)					
		2	3	4	5	6	7
Corn	0.5	1.0	1.6	2.1	2.6	3.1	3.6
Sunflower	0.5	0.9	1.4	1.8	2.3	2.7	3.2
Rapeseed	1.4	2.7	4.1	5.4	6.8	8.1	9.5
Soya	0.9	1.7	2.6	3.4	4.3	5.2	6.0
Groundnut	0.8	1.6	2.4	3.2	3.9	4.7	5.5

From this analysis, mothers who use home-modified animal milk as their primary mode of replacement feeding should also be advised to include some vegetable oil per day in

their infants' diet. Soybean oil is the preferred form of oil for the reasons stated above. Corn, sunflower, rapeseed or groundnut oil could be used if soy oil is not available. Quantities given should be adjusted according to the type of oil used and the child's body weight. This oil could be mixed with milk feeds or given directly to the child as a medicine if this is more acceptable. This oil should replace some of the sugar present in the modified milk recipe, one ml of oil (~ 0.9g) replacing 2g of sugar.

Vitamin and mineral supplements for home-modified animal milk

It is necessary to boil fresh animal milk before feeding it to young children to reduce curd tension and improve its digestibility[13], to reduce the risk of intestinal bleeding[14] and also to kill possible pathogens. In the process, some heat-sensitive vitamins will be destroyed. Scurvy and other vitamin deficiencies were quite common in rich countries in children fed boiled unfortified milk before the introduction of modern fortified infant formulas. As a result, commercially-produced infant formulas have added vitamins and minerals. Also, some minerals present in cow milk are in insufficient quantity or are poorly absorbed compared to breast milk. Hence, vitamins and minerals should also be provided to infants fed home-modified cow milk. The dose should correspond to the daily recommended nutrient intakes (RNI) for children aged up to 6 months[15,16] (Table 5). Iron is a special case, however, as iron requirements may be higher for artificially fed infants, especially when they have a low birth weight and are born to iron-deficient mothers. In this case, iron should be provided, although there is no theoretical requirement for breastfed infants.[17] The addition of iron to milk feeds of non breastfed infants below 6 months is advised in current guidelines.

There are two options to provide these micronutrients.

- ***Addition of a mineral and vitamin supplement to modified animal milk***

Current UN guidelines give the composition of a mineral and vitamin mix designed to be added to 100 kcal of modified milk. A dose adjusted for 100 kcal implies the use of multiple sachets per day, which would result in high packaging costs. To our knowledge, this supplement was never produced or distributed. Another option is to use a larger dose, for instance to prepare sachets suitable to fortify 500 kcal of modified animal milk. However, this leads to another technical difficulty: as young infants need feeds less than 500 kcal, this dosage of the supplement requires that milk should be stored after preparation, which is unsafe. There seems to be no easy technical solution to adding vitamin and mineral supplements to the home-modified animal milk.

- ***Use of an adapted supplement given directly to the young infant once a day***

Infants can also be given a single dose of a mineral and vitamin supplement, once a day, as a drug or mixed with a feed, as is most convenient. This supplement could be in powder form or made as a self-dissolving tablet, or it could be a syrup. As the estimated micronutrient requirements are the same for the age group 0-6 months, this seems a possible technical option.

If iron is added to the supplement, the safety of this approach could be a concern. There is a theoretical possibility of inducing a peak of unbound iron in serum after giving a dose, increasing the risk of infections, and in particular malaria, when iron is given in a daily dose, especially when not mixed with food.[18]

Table 5 WHO/FAO recommended daily nutrient intake for children less than 6 months

	Recommended nutrient intake 0 to 6 months
Minerals	
zinc	2.8-6.6 mg
copper	0.33-0.62 mg
iodine	90 µg
selenium	6 µg
Vitamins	
Vitamin A	375 µg
Vitamin D	5 µg
Vitamin E	2.7 mg
Vitamin K	5 µg
Vitamin C	25 mg
Vitamin B1	0.2 mg
Vitamin B2	0.3 mg
Niacin	2 mg
Vitamin B6	0.1 mg
Folic acid	80 µg
Vitamin B12	0.4 µg

Conclusions

Modifying animal milk for feeding infants below the age of six months raises difficult technical challenges. First, the currently-recommended recipe would need to have an increased essential fatty acid content. This involves adding daily small amounts of

vegetable oil in quantities that would need to be adjusted to their essential fatty acid composition and to the weight of the child. The feasibility of this approach has never been tested in the field. Second, the present recommendation of adding a mineral and vitamin mix to the recipe has not proved feasible to implement in practice, even on a pilot scale. Giving a mineral and vitamin supplement once a day to the child as a drug or mixed with a feed might be possible, although the safety of this approach would be a concern if this supplement contains iron.

In view of the technical difficulties of formulating and preparing a nutritionally adequate recipe for home-modified animal milk, and in view of the lack of data regarding the safety of this milk for replacement feeding of infants below the age of six months, home-modified animal milk should not be recommended as a feasible and safe long-term replacement feeding option. Only in situations where access to commercial infant formula has been temporarily interrupted should home-modified animal milk be considered for short-term feeding of non-breastfed infants below the age of six months.

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