



Assessment of the energy content of human milk administered to very low birth weight infants

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Abstract

Objective: To evaluate and compare the energy content in fresh and processed human milk administered to very low birth weight infants born in the Instituto Fernandes Figueira.

Methods: Samples of 0.5 ml of fresh and processed human milk were evaluated as for the fat percentile and energy content, which was calculated by mathematical formulas. Four hundred and sixty two human milk samples were analyzed, 401 of processed human milk and 61 of fresh human milk.

Results: The median and the standard deviation of the fat percentile checked was $2.9 \pm 1.2\%$ in the processed samples and $8.9 \pm 4.6\%$ in the fresh samples ($p < 0.001$). The median and the standard deviation of the energy content calculated was 53.6 ± 7.2 kcal/100 ml in processed samples and 85.9 ± 27.9 kcal/100 ml in fresh samples ($p < 0.001$).

Conclusion: The processed human milk samples had less energy content and less fat than fresh human milk samples suggesting that the complex processes of the human milk manipulation and administration can determine losses in energy content.

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Introduction

Human breast milk is the ideal food for any newborn infant because of its digestibility, balanced chemical composition and capacity to generate immunity.¹ Its use has been greatly encouraged in neonatal intensive care units (NICU), including both milk extracted from the mother's breast and immediately administered to the newborn infant (fresh or raw human milk – RHM) and milk that has been stored in a milk bank (processed human milk – PHM).

In cases in which a mother finds herself separated from her child or when a baby is incapable of suckling at the breast, the collection and stocking of human breast milk has been stimulated.²

Nevertheless, the use of exclusive human milk to feed very low birth weight newborns (VLBW) infants has been associated with inadequate weight gain and nutritional deficit during hospitalization.³ A number of different causes may contribute to this poor performance, primarily the large variety in lipid content. This variability is related to the methods used to collect, store and administer human milk, among other reasons.^{2,3}

The employment of strategies that can test the energy content of human milk at neonatal centers could contribute to its being maintained as the food source of choice for babies avoiding the use of formula.

The most commonly used method for determining the energy content of human milk, the creamatocrit technique, was proposed by Lucas in 1978 and adapted by Wang et al.

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in 1999, and consists of centrifuging milk samples, measure the quantity of fat that is present and, by means of mathematical calculations, determine its energy content.^{4,5}

The objective of this study is to assess and compare the energy content of the RHM and PHM given to VLBW infants at the *Instituto Fernandes Figueira* (IFF).

Methodology

During the period from January to October in 2003, samples of RHM (mature milk produced after the 14th day of lactation) and PHM were assessed as administered to VLBW infants in weight gain phase with no active diseases and clinically stable.

Samples were collected from all of the human milk (both types RHM and PHM) offered to preterm infants at times between 9 and 15 hours, the period during which the greatest number of mothers are present at the NICU of the IFF.

The PHM samples were collected from the receptacles sent to the NICU immediately before being offered to the newborn infant; the milk, therefore, had been collected, pasteurized and frozen at the human milk bank and, at a later date, sent to the lactation center, being defrosted, heated, distributed and supplied to the NICU. Milk samples that presented coagulation to the naked eye were discarded. Before collection, homogenization of the material was performed with manual movements as recommended by Wang *et al.*⁴

The RHM samples were collected by means of manual expression from the breast, after the newborn infant had suckled for 10 minutes or, if the baby was not yet capable of suckling, after 10 minutes' manual expression (intermediate milk). These samples were collected directly from the breast as soon as a thick drop was produced.

All samples (RHM and PHM) were taken in triplicate (each in the form of 0.5 ml of human milk – three glass capillaries: 75 x 1.5 mm) and immediately centrifuged for 15 minutes (FANEM® centrifuge – model 250).

The method employed to determine the energy content of the human milk samples consists of centrifuging samples of milk, measure the quantity of cream (fat) that is present and, by means of particular mathematical calculations, determine its energy content.^{4,5} The mathematical formulae employed for the energy calculations used for the milk samples are as follows:

- **Raw Milk:** energy (kcal/dl) = 5.99 x creatocrit (%) + 32.5;
- **Frozen Milk:** energy (kcal/dl) = 6.20 x creatocrit (%) + 35.1.

The total column heights and the height of the cream column were measured for every capillary with the use of a pachymeter caliper; in this way the percentage of cream in the whole milk was determined. The same procedure was executed by three different observers, after tests for intraobserver and interobserver agreement had been performed. ($k = 0.94$ and 0.87 , respectively).

Results were discarded if the determination of cream percentage was identified as having been compromised after centrifuging. For example, cream columns that were not well defined or significant discrepancies between the heights of different columns from the same sample.

The caloric contents of RHM and PHM were compared using SPSS 9.0 statistical software and the Kruskal-Wallis non-parametric test.

The study design was approved by the IFF Committee for Ethics in Research, and every participating mother gave formal consent in advance to their inclusion in the study.

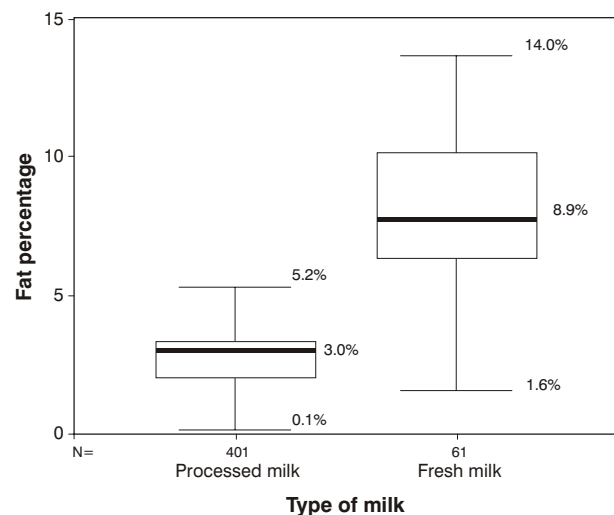
Results

Four hundred and sixty-two samples of human milk were collected: 401 of PHM and 61 of RHM.

The mean, standard deviation and median cream percentages were as follows:

- for the processed milk group: mean was $3 \pm 1.2\%$ and median was 2.9%;
- for the raw milk group: mean was $8.9 \pm 4.6\%$ and median was 7.7%.

The difference between means was significant ($p < 0.001$) (Figure 1).



* The highest and lowest values of each figure express the maximum and minimum values; the box represents 50% of the sample collected; the other 50% are distributed between the box and the highest and lowest values (25% for each side); the broader line in the box represents the mean.

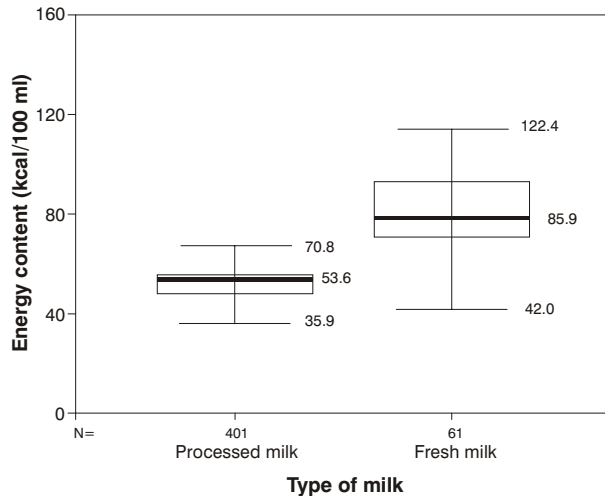
Figure 1 - Distribution of cream percentages in the groups*

The mean, standard deviation and median of the calculated energy contents were as follows;

- for the processed milk group: mean was 53.6 ± 7.2 kcal/100 ml and median was 53.6 kcal/100 ml;

- for the raw milk group: mean was 85.9 ± 27.9 kcal/100 ml and median was 78.5 kcal/100 ml.

The difference between the means was significant ($p < 0.001$) (Figure 2).



* The highest and lowest values of each figure express the maximum and minimum values; the box represents 50% of the sample collected; the other 50% are distributed between the box and the highest and lowest values (25% for each side); the broader line in the box represents the mean.

Figure 2 - Distribution of the energy content values in the groups*

Discussion

Human milk is a homogenous mixture that meets the nutritional, metabolic and digestive needs of term infants in addition to providing hormones, essential amino acids and immunological factors, making it the best choice for the nutrition of newborn infants, especially premature and severely ill ones.³

Despite innumerable advantages, several different studies have demonstrated that exclusive use of human milk to feed VLBW infants results in reduced growth velocity when compared with artificial formula milk. This fact might be explainable by an insufficient concentration of certain nutrients in human milk, primarily proteins, lipids and electrolytes.^{3,6,7} Even in the face of this inadequacy human milk is still recommended for VLBW infants because of the benefits reaped in stimulating the organism's defense mechanisms and the unique profile of its fat content.³

In order to remain available to have her milk collected at the time of administration to her baby a mother must overcome a number of difficulties. The high frequency of collections – normally every 2 hours, the inadequate accommodations for the mother during the usually long period of VLBW infants' hospital stay, the possible existence

of other children also requiring her care and the absence of nipple stimulation by the newborn infant suckling are all factors making the practice more difficult.⁸ Breast stimulation with massage and periodic pumping soon after the baby's birth, in addition to support from the family and from the health team, are essential to long-term milk production.³

Milk collected directly from the mother and given to the baby with no treatment (RHM) is considered by many authors to be the best option for feeding VLBW infants, since in this state it offers a greater concentration of proteins and electrolytes, primarily sodium, chloride, magnesium and iron, in addition to the higher fat content.⁹⁻¹³

In a recent study, human milk collected by manual expression immediately before creatocrit was performed (RHM) exhibited a mean fat percentage of $2 \pm 1.9\%$ when collected at the start of suckling, $9 \pm 2.8\%$ after 5 minutes' suckling, $11.4 \pm 4.6\%$ at the tenth minute and $14.3 \pm 3.8\%$ at the end.¹³ In the study made of the samples collected at the IFF, the creatocrit of RHM collected 10 minutes after the start of suckling or after 10 minutes of pumping by manual expression was $8.9 \pm 4.6\%$. This high level of fat could be explained by the manual pumping of the breast milk and also by the time allowed to pass before collection, since the body fat percentage increases while feeding.^{3,13} The caloric content of the RHM was 85.9 ± 27.9 kcal/100 ml, which is enough for adequate VLBW infants growth according to American Academy of Pediatrics recommendations.¹⁴

Some concern may be directed at the possibility of RHM exposing preterm newborn infants to bacteria. There is evidence to prove that human milk maintains its bacteriostatic characteristics unaltered for up to 6 hours if stored at a temperature between 19 and 26 °C or for up to 48 hours if stored refrigerated, which emphasizes the safety of giving raw milk at the time of collection.^{2,15}

When the mothers of premature newborn infants are unable to produce milk in sufficient volume to meet the needs of their babies, it becomes necessary to use PHM.⁸ The only type of PHM that is safe to give to premature babies is that provided by milk banks. These are centers specialized in the promotion and encouragement of breastfeeding, that are responsible for the collection, processing and quality control of donated human milk.^{16,17}

Before being given to the newborn infants, under prescription, the PHM is exposed to a complex process: pre-storage, defrosting, pasteurization, refreezing, re-defrosting and heating. Throughout this process significant energy losses are detected, primarily from the fat content which is the main caloric-energetic source of human milk.^{2,3} The pasteurization process does not reduce the nutritional content of human milk, but it does reduce its specific bioactive function.¹⁸ The process of freezing and defrosting, however, results in the bursting of fat globule membranes resulting in coalescence and facilitating adherence to flask walls and to utensils used to feed the newborn infants (plastic equipment and syringes).^{9,12,19-21} As a consequence of this, if milk is infused by gastric tube, infusion syringes are held horizontally and milk is not homogenized before feeding, losses can reach 34% of the fat content.^{4,22}

In clinical practice, it is not just expected that a preterm infant will exhibit growth velocity similar to that of a fetus or infant of the same post-conceptional age, but great effort is actually employed to achieve this.²³ This is a great challenge for VLBW infants, since as they are exposed to intense stress for extended periods causing increased calorie requirements.^{24,25} A study of the longitudinal growth of preterm newborn infants in hospital, undertaken by Ehrenkranz *et al.* in 1999, found evidence of great difficulties in mimicking the fetal rate of growth, particularly when adequate nutritional provision is not prioritized.²⁶

The “nutritional programming” theory states that inadequate nutrition for premature newborn infants or during the early stages of infancy had negative repercussions in adult life and can cause hypercholesterolemia, diabetes and arterial hypertension.²⁷⁻²⁹ When all these concepts are taken in association, constant evaluation of the energy content of the milk offered to premature newborn infants is recommended.²⁹

The study undertaken of the milk samples collected at the IFF demonstrates that the energy content of intermediate milk extracted at the time it is to be given to the newborn infant (RHM) is superior to PHM, presenting a mean value of 85.9 kcal/100 ml in comparison to 53.6 kcal/100 ml for PHM ($p < 0.001$). Other studies have tested the creatinocrit value in samples of PHM and found it to be lower than in RHM.³⁰⁻³² Wang relates that freezing and defrosting human milk is associated with reductions in the creatinocrit, however the effects of these processes on the lipid, carbohydrate and protein concentrations were not found to be significant.⁴

The calculations made to ascertain the energy content of the PHM samples tested in this study demonstrated that the caloric content of the samples was not the most suitable for guaranteeing the desired nutritional support to VLBW infants.¹⁴

Nutritional support is recognized as one of the principal pillars supporting the treatment of newborn infant. Therefore, assuring the quality of the milk offered to these babies is fundamental to guaranteeing “normal” growth.

Concern over the low rate of weight gain of newborn infants fed exclusively on human milk often leads to the use of milk-based formula with no prior evaluation of the quality of the human milk being offered.

The present study proposes that the energy content of human milk be assessed immediately before its administration to the newborn infant in an attempt to avoid human milk being abandoned in favor of a milk-based formula with no attempt to improve its caloric and nutritional content.

Although the milk bank at the IFF uses the creatinocrit technique to control the lipid content of their PHM, the milk given to premature newborn infants is often processed at the lactation center after this evaluation has taken place and before it is administered, which may be one explanation for the reduced fat content of these samples.

The issue of insufficient weight gain in VLBW infants justifies the performance of further studies to identify the points at which energy content is lost from PHM and to find solutions to avoid these losses, thus improving conditions for exclusive human milk use.

Simple precautions during the feeding of human milk to the newborn infants can be effective measures for reducing the loss of calories caused by particles of fat clinging to the inside walls of equipment. These include holding syringes vertically, reducing the time taken for infusion of diets to the maximum extent possible and regular homogenization of the milk thereby allowing better calorie supply and, consequently, better weight gain.³ Additionally the fat content of the PHM could be stipulated in medical prescriptions.

Evaluation of the caloric content of the milk that actually arrives at the newborn infant and encouragement of the use of milk from the newborn infants own mother, associated with support that permits true maternal breastfeeding, even if not at every feed, could be the best way to deal with issues that have come up recently, such as how to feed ever-smaller and more premature newborns thus preparing generations more likely to develop in a healthy way.

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