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Goat and Cow Milk Infant Formula, Protein Quality Evaluation in Rats

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ABSTRACT

Infant formula products are mostly produced using protein from cow milk; goat milk also has a good source of protein. Owing to variations in protein content between human, cow, and goat milks, infant formula was formulated to be as similar as possible to human milk. In this study, goat and cow milk infant formulas were prepared by adding α -lactalbumin and it was directly compared to commercial infant formula protein digestion using growing rats. The nutritional value of these formulated diets was evaluated by estimating their proximate composition, the protein efficiency ratio (PER), corrected protein efficiency ratio (CPER), net protein ratio (NPR). The composition of the formulated diets indicated that satisfied legal nutrient content regulation and are within the range of recommended standards. The PER, CPER and NPR of formulated diets did not significantly ($P>0.05$) different and much closed to those of control. It was observed no significant difference due to milk type in the quality of protein. The protein quality of the formulated goat and cow infant formula were well comparable with those of commercial infant formula, the common infant diet over the world.

Keyword: goat milk infant formula, protein efficiency ratio, rats, α -lactalbumin.



INTRODUCTION

Breast milk is the ideal food for babies. However, when breastfeeding is not available or not sufficient; the option is high-quality infant formula. Most of the infant formulas are based on cow milk proteins. Nevertheless, there is increasing consumer demand for goat milk formula. Goat milk formula provided growth and nutritional outcomes for infants similar to that standard cow milk-based infant formula (Xu *et al.*, 2015; Zhou *et al.*, 2014).

Due to the differences in the composition of proteins, fats and carbohydrates between human, cow, and goat milks, infant formula has been designed to be closer in composition to human milk as possible (Goedhart & Bindels, 1994; Martin *et al.*, 2016). Many attempts have been done to improve the quality of infant formula such as: adding lactose and mixtures of vegetable oils as lipid sources. The whey:casein ratio in infant formulas has been adjusted to resemble that in human milk (Martin *et al.*, 2016). There are considerable differences in the protein composition in infant formula and human milk. Much of this difference is due to a lower concentration of α -lactalbumin in infant formula, which is found in higher concentration in human milk, as well as the presence of β -lactoglobulin, which is absent in human milk (Jackson *et al.*, 2004).

The amino acid composition of α -lactalbumin is well balanced and is recognized to have several physiologic effects, antimicrobial activity, enhanced immune and prebiotic functions, and increased absorption of trace elements (Sandström *et al.*, 2008). Therefore, supplementation of alpha-lactalbumin in goat milk formula is a step toward humanizing the protein composition of goat milk for infant feeding.

The Food and Agriculture Organization reported minimum protein quality requirements which should be

determined provisionally using the protein efficiency ratio (PER) or Protein Digestibility-Corrected Amino Acid Score (PDCAAS) and other methods that come available in the future (Joint, 2016). Therefore, the current study focused on comparing the quality of protein in goat and cow milk formulas supplemented with α -lactalbumin on the growth rate of rats by estimating the protein efficiency ratio (PER) and the net protein ratio (NPR).

MATERIALS AND METHOD

Materials:

Goat's milk was obtained from El-Serw Animal Production Research Station, Agricultural Research Center, Egypt. Cow's milk was obtained from the herds of the Faculty of Agriculture; Cairo Univ. Pure grade lactose was obtained from El-Gomhoriya Company, Cairo, Egypt. Commercial dried infant formulas, lecithin and vegetable oils were purchased from the local market.

Preparation of infant milk formula: Alpha-lactalbumin (α -La) concentrate was mixed with an amount of whole milk, 80:20 (casein:whey) containing an equal amount of protein to provide a ratio of caseins to whey proteins of 40:60. α -La was found to be the a major whey protein in this protein combination. Water-soluble materials including lactose and minerals were reconstituted in this protein mixture (milk with α -La) at 50°C. The vegetable oil mixture and emulsifier were heated to 60±5°C and added to the mixture of all the other ingredients and then stirred until completely mixed. The mixture was subjected to heat treatment to 85°C and then, cooled rapidly to the room temperature. Protein, fat and lactose in our formulations were based on the European Union guideline for infant formula (Koletzko *et al.*, 2005). Accordingly, 100 ml of liquid formula were selected which included 1.7 g protein, 3.5 g lipid and 6.5 g lactose.

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Chemical Analysis: Moisture, fat, ash and total protein contents of infant formula were determined according to AOAC.

Calculation of Caloric value:The caloric values were calculated by multiplying protein, fat and lactose contents by factors of 4.27, 8.79, and 3.87 kcal/g, respectively (FAO, 2002).

Biological value as a measure of protein quality: Twenty five female weaned albino rats of Wistar-strain (35 days old with an average body weight of 69±6g) were obtained from the Food Technology Research Institute, Cairo, Egypt; the rats were divided into five groups of 5 rats each. The experimental tested diets were casein as control, the nitrogen-free diet (negative control), commercial infant formula (CIF), cow milk formula (CMF) and goat milk formula (GMF); the diets were prepared at 10% protein level (N x 6.38). The diets consisted of a mixture of starch, 80.7%; sucrose, 8.9%; cellulose, 5.2% and corn oil, 5.2%, vitamins mix (1%) and minerals mix (4%). The rats were placed on an adaptation diet for a period of three days. Rats were housed in metabolic cages at room temperature of 24±2°C with a 12 h cycle of light and dark. The changes in weight and protein consumption over the 28 days were used to estimate protein efficiency ratio (PER), corrected protein efficiency ratio (CPER) and net protein ratio (NPR) according to the following formulas:

$$PER = \frac{\text{Weight gain of tested group}}{\text{Protein consumed}}$$

$$CPER = \frac{2.5}{\text{PER for casein}} \times \text{PER}$$

$$NPR = \frac{\text{Weight gain of tested group} + \text{weight loss of control group}}{\text{Protein consumed by test group}}$$

Statistical analysis: Data were analyzed statistically using the MSTAT-C (ver 2.10, MSU, USA) package on a personal computer. All experiments were carried out in triplicates. Differences were considered significant at P<0.05.

RESULTS AND DISCUSSION

1. Proximate composition:

Results of the proximate nutrient composition of the three formulations (cow milk formula, goat milk formula, and commercial infant formula) were calculated based on dry matter basis and relativity to energy ratio as shown in Table 1. The chemical composition of dry infant formulas was similar for the three infant formulas. The composition of formulated diet indicated that satisfied legal nutrient content regulation and are within the range of recommended standards. The Coordinated International Expert Group of European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) recommended in infant formulas, the total fat content is in the range of 4.4-6.0 g/100 kcal, the protein content based on milk protein should be between 1.8-3 g/100 kcal and the recommended total carbohydrates is in the range 9-14 g/100 kcal (Joint, 2016; Koletzko et al., 2005).

Table 2. Effect of feeding experimental diets on growth performance of rats.

| | Initial body weight (g) | Final body weight (g) | Body weight gain (g) | Protein intake (g) | PER | CPER | NPR |
|------------------|-------------------------|-----------------------|---------------------------|--------------------------|-----------|-----------|-----------|
| Casein (control) | 65.13± 6.30 | 136.58±15.99 | 71.45±18.62 ^{ab} | 27.10±5.20 ^a | 2.60±0.29 | 2.54±0.09 | 3.83±0.16 |
| CIF | 70.06±4.475 | 129.96±8.92 | 59.90±6.751 ^b | 22.43±1.161 ^b | 2.63±0.36 | 2.68±0.19 | 4.07±0.52 |
| CMF | 66.42±7.17 | 143.46±11.64 | 77.04±5.49 ^a | 27.64±0.00 ^a | 2.79±0.20 | 2.68±0.19 | 3.95±0.20 |
| GMF | 69.34±6.14 | 142.22±8.31 | 72.88±7.13 ^{ab} | 26.90±0.68 ^a | 2.80±0.23 | 2.69±0.22 | 4.03±0.22 |
| LSD | 7.34 | 17.32 | 14.79 | 3.59 | 0.40 | 0.36 | 0.45 |

Results are presented as means±SD (n=5). Mean values within a row with unlike superscript letters were significantly different (P<0.05). CIF: commercial infant formula, CMF: cow milk formula, GMF: goat milk formula, PER: protein efficiency ratio. LSD = least significant differences.

Table 1. chemical composition of infant formulas used in the study on dry weight basis and on energy ratio

| Type of formula | Energy | Fat | | Protein | | Carb%. | | Ash |
|-----------------|------------|-------|------------|---------|------------|--------|------------|------|
| | Kcal /100g | % | g/100 kcal | % | g/100 kcal | % | g/100 kcal | % |
| CIF | 523.81 | 28.57 | 5.45 | 13.15 | 2.51 | 55.95 | 10.68 | 2.32 |
| CMF | 531 | 30.65 | 5.77 | 12.64 | 2.38 | 53.64 | 10.10 | 3.07 |
| GMF | 530.60 | 30.53 | 5.75 | 12.98 | 2.45 | 53.44 | 10.07 | 3.05 |

CIF: commercial infant formula, CMF: cow milk formula, GMF: goat milk formula

2. Weight Gain and Growth Rate

Figure (1) shows the body weight gain for rats fed with casein as control and commercial infant formula (CIF) as the reference followed by formulated diets of cow milk formula (CMF) and Goat milk formula (GMF) during the 28 days of trial. A liner increase of the body weight been observed in casein control group and three mentioned treatments (Figure 1). The body weight showed higher values in the CMF, GMF and control groups compared to the CIF group (Table 2).

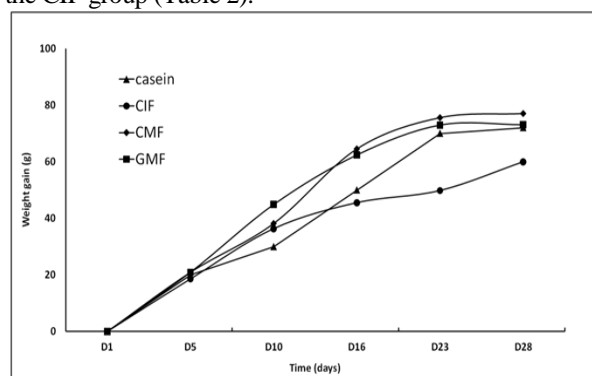


Figure 1. Change in body weight gain (g) of Rats Fed on casein as control, commercial infant formula (CIF), cow milk formula (CMF) and goat milk formula (GMF) for 28 Days.

The cow milk formula group showed significant (p<0.05) higher values of body weight gain starting from the 10th day till the end of experiment compared to the commercial infant formula group, values being 77.04 and 59.90 g, respectively. There weren't any disease and mortality which could also be used to assess the safety of formulated diets.

3. Protein quality evaluation

Protein quality of casein and experimental diets as measured by protein efficiency ratio (PER), corrected protein efficiency ratio (CPER) and net protein ratio (NPR) are presented in Tables (2). The PER, CPER and NPR of the experimental diets were determined using data of body weight gain of rats and protein intake as shown in Table (2).

The protein intake (Table. 2) showed the lowest value, 22.43 g in the CIF group compared to casein, CMF and GMF groups being, 27.1, 27.64 and 26.9 g in three groups, respectively (p<0.05).

The decreased value of the protein intake in the CIF group might be the reason of the lower body weight gain of the experimental rats. The PER, CPER and NPR showed slightly lower values in the control group (casein) compared to its values in the CIF, CMF and GMF groups and differences among all treatments were not significant ($P < 0.05$). Since, the NPR values attribute protein used for both growth and maintenance, the NPR values of all sources of tested protein were higher the PER values (Table 2). This was explained by the fact protein needed to avoid weight loss in rats fed the protein-free diet is equal to the protein necessary for maintenance (Sarwar, 1997). These results were in agreement with those obtained by (Grant *et al.*, 2005; Rutherford *et al.*, 2006; Xu *et al.*, 2015b; Zhou *et al.*, 2014).

CONCLUSION

The type of milk used in preparing the infant formulas either cow or goat milk did not affect the quality of infant formula especially the protein. The infant formulas prepared were comparable with the commercial infant formula in quantity intake, growth and protein efficiencies with no mortality recorded.

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تقييم جودة البروتين لتركيبية الاطفال المستخدم فيها لبن الماعز ولبن الابقار في الفئران

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يتم تصنيع منتجات لبن الأطفال في الغالب باستخدام بروتين اللبن البقري؛ وأيضًا يعتبر لبن الماعز مصدرًا غني للبروتين. نظرًا للاختلافات في تكوين البروتينات بين لبن الأم ولبن البقري ولبن الماعز، فقد تم تصميم لبن الأطفال ليكون أقرب إلى لبن الأم قدر الإمكان. في هذه الدراسة، تم اعداد لبن اطفال من لبن الماعز واللبن البقري عن طريق إضافة بروتين الفال-لاكتوبليومين وتمت مقارنتها بهضم بروتين لبن الأطفال التجاري باستخدام الفئران النامية. تم تقييم القيمة الغذائية لهذه الأنظمة الغذائية من خلال تقدير تركيبها الكيماوي، ونسبة كفاءة البروتين (PER)، ونسبة كفاءة البروتين المصححة (CPER)، ونسبة البروتين الصافي (NPR). أشارت تركيبية الأنظمة الغذائية المصاغة إلى استيفاء اللوائح القانونية للمكونات وضمن نطاق المعايير القياسية الموصى بها. لم تتواجد فروق معنوية ($P > 0.05$) في كل من PER و CPER و NPR للتركيبات الغذائية بشكل كبير وكانت قريبة من تلك الموجودة في الكنترول. لم يكن لنوع اللبن تأثير معنوي في جودة البروتين. كانت جودة البروتين في تركيبية لبن الماعز واللبن البقري للرضع قابلة للمقارنة بشكل جيد مع تلك الموجودة في لبن الأطفال التجاري، وهو الغذاء المتعارف عليه للرضع في جميع أنحاء العالم.