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COMPARATIVE ANALYSIS OF NUTRITIONAL VALUE OF HUMAN BREAST MILK, LOCAL COW, GOAT MILK AND BABY FORMULA

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ABSTRACT

Comparative studies between cow, baby formula, goat and human milk was carried out, by determining their chemical and mineral compositions. Three samples, each of cow milk, goat milk, and two milk samples of human breast milk and a baby formula were obtained at random from cows; goats; and a synthesized baby formula purchased, while human milk was obtained from healthy lactating women (after 2nd and 3rd months of lactation respectively). Chemical constituents as protein, fat, carbohydrates, moisture, and ash were determined. Minerals contents as calcium (Ca), iron (Fe), zinc (Zn), and magnesium (Mg), were measured in the ash. The result showed that, human milk contains the lowest protein and ash content. Goat milk has the highest fat content, but somewhat similar to human, cow and baby formula in concentration. Human milk contains the highest carbohydrate and lactose content (7.24% carbohydrate, of which 4.70% are lactose, i.e. it represent 94.46%). The result also showed that the human milk contains the lowest concentration of Ca, Fe, Zn and Mg. Goat milk has the highest Ca and Mg contents of the four studied. Samples varied widely to some extent, but equally shared closer proximity to some extent. Cow milk, baby formula and goat milk cannot replace human breast milk but it may complement it.

Keywords: Milk, human-breast, cow , goat, baby-formula, proximate analysis.

1. INTRODUCTION

The value of goat milk in human nutrition has so far received very little factual and academic attention (1; 2) despite its medical need for some people especially infants afflicted with various ailments, including cow milk proteins sensitivities (3; 4). Goat milk proteins and fat have many significant differences in their composition from the milk of other mammalian species, especially in relative proportions of the various milk proteins and fats, and in their genetic polymorphism (5). Goat milk have shorter rennet coagulation time, less resistance to heat treatment, curd firmness is weaker and chess yield are less, which might explain significant difference to cow and other milk in digestion by infants and patients which traditionally have been explained by the “homogenized” nature of goat milk fat (6;2).

Human milk is believed to provide all the nutrients and essential minerals and trace elements (micro-nutrients) that are required by the normal term infant growths, until weaning. With a few exceptions, excessive micronutrients supplies to the mother or a moderate deficiency in her diet

Vol. 4, No. 01; 2019

ISSN: 2456-8643

do not greatly alter the supply to the infants. Thus, the infants are well protected by maternal homeostatic processes (7). The composition of human milk varies over the course of lactation and in each individual. Human's milk is markedly different from cow's milk, both in terms of macro and micro nutrients. It is noteworthy that of each species has a particular individual pattern of minerals, which may be a pointer of relative nutritional importance of the element.

Milk is an emulsion or colloid of butter fat globules within a water based fluid. Each fat globule is surrounded by membrane consisting of phospholipids and proteins; these emulsifiers keep the individual globules from the fat-digesting activity of enzymes found in the fluid portion of the milk. In un-homogenized cow milk, the fat globules average, about four micrometer across.

Opaque white color of milk due to deflect light is attributed to both fat globules and smaller casein micelle. Carbohydrate lactose gives milk its sweet taste and contributes about 40% of whole cow milk's calories.

2. MATERIALS AND METHOD

Sample Collection

Three samples, each of cow milk, goat milk, and two milk samples of human breast milk and a baby formula, were obtained at random from; cow, goats in Nagari's farm, keffi, and a synthesized baby formula (SMA-GOLD) purchased from Keffi main market, while human milk was obtained from healthy lactating women (after 2^{nd} and 3^{rd} months of lactation respectively) in keffi metropolis, Nasarawa state.

The samples were collected using a sterile culture bottle and transported to chemistry advance laboratory, Sheda Science and Technology Complex (SHESTCO), F.C.T, Abuja, immediately.

Protein determination

Crude protein was determined using micro-kjedahkl method described by AOAC ,1990 (8). A know weight of the samples were placed in kjedahkl flask and about 200mg catalyst mixture was added.10cm3 of concentrated sulphuric acid was then added to the content in the flask, and heated to digest, for 3hrs, after which it was allowed to cool and made up with distilled water to 100cm3.

10cm3 aliqout of the digest solution was distilled and pipette into the distillation chamber of micro-kjedahl distillation apparatus.10cm3 of 40% sodium hydroxide solution was added and steam distilled into 10cm3 of 2% boric acid containing mixed indicator, then titrated with standard 0.01N HCL to grey end point.

Protein was determined by first calculating the percentage nitrogen which is given as;

$$\% \text{ Nitrogen} = \frac{0.014 \times M \times V \times 100}{\text{Weight of sample}}$$

Where

M = Molarity of Acid (0.5)

V = End point of titration

Vol. 4, No. 01; 2019

ISSN: 2456-8643

Crude protein is then calculated by multiplying the % Nitrogen with 6.25 and adding it to the crude protein.

i.e. crude protein= % nitrogen × 6.25

Where, 6.25 is the conversion factor for milk protein.

Ash Content Determination

The procedure for ash content determination was modified from the work of James, 1995 (9). 2g of the solvent sample was weighed (w_1) into a pre-weighed crucible (W_0) and placed into a lanton muffle furnace at 550^0C for 5hours. The ash was cooled in a desiccator and weighed (W_0). The weight of the ash was determined by the difference between solvent sample, pre-weighed and the ash in the crucible. Percentage ash obtained by the equation below;

$$\text{Ash (\%)} = \frac{W_2 - W_0}{W_1 - W_0} \times 100$$

Where

W_0 =weight of the empty crucible (g)

W_1 =weight of the sample solvent + empty crucible (g)

W_2 =weight of the dried sample + empty crucible (g)

Determination of Moisture Content

The % moisture lost was measured due to drying at a temperature of 105^0C. According to Udo and Oguwele, 1986(10) method, with modifications, 1g of the solvent sample was weighed (W_1) into pre-weighed crucible (W_0) and placed into a hot dried oven at 105^0C for 3hours. The crucible were removed, cooled in desiccators and weighed. The process of drying, cooking and weighting were repeated until a constant weight (W_2) was obtained. The weight loss due to moisture was obtained by the equation:

$$\text{Moisture (\%)} = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

Where

W_0 = weight of the empty crucible (g)

W_1 = weight of the sample solvent + empty crucible (g)

W_2 = weight of the dried sample + empty crucible (g)

Ether extraction

Crude lipid content in the sample was extracted using soxhlet extractor procedure described by udo and oguwele, 1986 (10). 2g of sample was weighed and transferred into the fat-free extraction thimble, which was pluged tightly with cotton wool, and placed in the extractor. About 150cm3 of petroleum ether (B.P 60-80) was added to the flask until it siphons over once, after which more ether was added until the barrel is half full. The condenser was replaced and placed on heat so that the ether boils gently and allowed to siphon for at least 8hrs.after siphoning, it was drained well, and the thimble dried in the oven. The condenser and flask were

Vol. 4, No. 01; 2019

ISSN: 2456-8643

replaced back and re-distillated until the flask was practically dry. The flask which now contains the oil extract was detached and concentrated in the oven to a constant weight.
2g of the sample was weighed (W_0) into a crucible, and was then dried for three hours in an oven at a temperature of 105^0C and weighed (W_2). It was then weighed (W_1) to get the percentage yield of the crude fat which was calculated using the equation below;

$$\text{Crude liquid (\%)} = \frac{W_1 - W_2}{W_0} \times 100$$

Determination of carbohydrate

The method of James, 1995 (9) was adopted, where the total proportion of carbohydrate in the oil yield sample which was obtained by calculation using the percentage dry method. This is by subtracting the % sum food nutrient, % protein, % crude liquids, % crude fibre, and % moisture/% ash from 100%. This is done by using the equation below;

CHO (%) = 100% - (% crude protein + % crude liqid + crude fibre + % ash + moisture)

Minerals Determination

Magnesium (atomic number 12, atomic weight 24.305)

1g of magnesium metal was dissolved in 50ml of 5M HCL, and then diluted to 1L in a volumetric flask with deionized water. It was stored in a polythene bottle and absorbance was read at 285.2nm.Iron (atomic number 26, atomic weight 55.847)1g of iron powder was dissolved in 20ml of 5M HCL and 5ml of nitric acid(specific gravity 1.42) was added, then diluted to 1L in a volumetric flask with deionized water. It was stored in a polythene bottle and absorbance was read at 372nm. Zinc (atomic number 30, atomic weight 65.37) 1g of zinc was dissolved in 30ml of 5M HCL, and then diluted to 1L in a volumetric flask with deionized water. It was stored in a polythene bottle and absorbance was read at 324nm. Calcium (atomic number 20, atomic weight 40.08) 2.5g of calcium carbohydrate was dissolved in 25ml of 1M HCL drop-wise in other to avoid effervescence. The solution was then diluted to 1L in a volumetric flask with deionized water and then stored in polythene bottle. Absorbance was read at 290nm.

Statistical calculation

A test of significance (P-test) was carried out on the mean of each of the proximate analysis in each of the sample using a computer software- Statistical Package for Social Sciences version 15.0 (SPSS 15.0) which showed that there was a significant difference ($p<0.05$) in the proximate analysis on the various milk.

3.RESULTS AND DISCUSSION

Table 1 and 2 showed the chemical composition and elemental or mineral composition of human breast milk, cow milk, goat milk and baby formula expressed in g/100g. human milk contain significantly less protein content than other forms of milk, with its content similar to that of goat milk and baby formula. It also has higher carbohydrate content than the other forms of milk with higher calories of 74.13k/cal.

Vol. 4, No. 01; 2019

ISSN: 2456-8643

The result of goat milk content agrees with work of some researchers (11; 12). It disagrees with (1) where they found that the main components of goat milk are similar to those of cow milk but differs as to particular physical and chemical properties (small size of fat globules, higher content of short and medium chain fatty acids). A significant minority of infants (≥ 8% in 1 year old infants) (4) are allergic to one or more of the constituents of cow's milk so goats' milk could be equal or superior to cow's milk (10;9).

Table 2 shows the mineral content expressed in (mg/100g). Cow milk, goat milk and baby formula milk had highest minerals contents compared to human breast milk with significant difference between them. Goat milk provides a great amount of calcium (131.39), while breast milk has the lowest (33.39). Calcium intake is important for maintenance of bone health and may reduce risk of osteoporosis. It can be obtained from foods naturally, including milk. It helps in massages signaling, muscle contraction, blood clothing e.t.c (11). The result of calcium in cow, goat and human agrees with the work of (12-14). But that of cow disagrees with the work of Holland *et al*., 1998 (15). Calcium content in human disagrees with work of some researchers (16-18). They provide; infants/ serving ≤6months with 194.27, 155.1% of their RDA (DRI); infants ≥ 1year with 151.1, 120.63 of their RDA (DRI) respectively, while human milk provide infants with 38.53, 29.96% of their RDA (DRI) respectively. Goat milk contains 3-4.5 times of the human milk content. They provide adults (male and female) with 27.84 – 40.8% of their RDA (DRI).

Milk provide >100% of their need from cow and goat while human milk provide ≈ 50%. This ratio decreases with age where it reaches 1.33-5.14% with infants' ≤ 1 year. Even more, milk provide adult male with double (twice) as female although the ratio is small (male: 1.82-7.07% and female: 0.81-3.14%).

Human milk had significantly lower content of zinc (0.18) while cow and goat milk had a significantly higher levels (0.38 and 0.33 respectively) somewhat a comparable concentration. Zinc is essential part of more than 200 enzymes involved in digestion, metabolism, and reproduction and wound healing (11). This could probably be due to depletion of maternal zinc stored (11). They (cow and goat milk) provide: infants ≤ 6 months with 29.88-63.64% of their RDA (DRI); infants ≤ 1 year with 19.92-42.43 % of their RDA (DRI), while human milk provide infants with 20.59, 13.73 % of their RDA (DRI) respectively. Goat milk contain 7 times human milk content of Zn. Goat milk provide adult (male or female) with ≈ 39.5 % of their RDA (DRI). Human milk had the lowest concentration of magnesium (3.61). Magnesium activates 100 enzymes and play role in over 300 enzyme reactions in the body, many of which are directly related to cardiovascular health and helps nerves and muscles function. Magnesium contents of cow and goat milk agrees with some studies (12-15). Magnesium content of human milk agrees with (16) and disagrees with (12; 13,17-19). Goat milk provides: infants ≤ 6 months with 246.3, 115.55% of their RDA (DRI); infants ≤ 1 year with 98.52, 46.22 of their RDA (DRI) respectively, while human milk provide infants with 28.59, 11.43 % of their RDA (DRI) respectively. Cow and goat milk contain 8.6-4 times human milk content of Mg. They provide adult male with 17.59, 7.99, 8.25%, and adult female with 23.09, 10.49, and 10.83% of their RDA (DRI).

Vol. 4, No. 01; 2019

ISSN: 2456-8643

It is noteworthy that milk of each species has a particular or individual pattern of chemical and minerals composition, which may be a pointer of relative nutritional importance of the element and the chemical content. Human milk contained the lowest protein content compared to other species, and this reflects the slower growth of the infant relative to the other species. This is though still adequately good enough to contain and maintain proper baby's growth. Also, the lower protein content of human milk lowers the milk buffering capacity and hence the osmotic stress to the kidney. The lower osmotic stress is important for kidney function, which has not fully developed in new born or younger infant. The high content of protein for other milks put a strain on an infant's immature kidney. In addition, the protein and fat in other milks are more difficult for an infant to digest and absorb than breast milk (20; 21). Fat content of human milk is the most suitable source of energy. The average energy requirements of the newborn are about 100 Kcal/kg BW, while for adult ≈ 40.48 Kcal/kg BW, i.e. newborn infants require 2-3 times as adults, which is explained by the newborn's high basal metabolism. Human milk is characterized by higher carbohydrates content; usually the disaccharide lactose, which has a low osmotic value per unit of weight, which is relevant to the infant's water balance. Infants has a relatively high water requirements because their relatively large body surface and hence a high evaporation. Lactose decomposes in the gastro-intestinal canal at a relatively slow rate, consequently, part of it reaches the terminal ileum and colon unsplit and could contribute to the formation of the so-called bifidus flora (22; 23). The fat globule in goat's milk does not cluster together due to absence of agglutinin, which makes goat's milk easier for an infant to digest. Also goat's milk does not contain many of the allergens found in cows' or other milks, and yet goat's milk is unsuitable for infants as it can cause intestinal irritation and anemia (24; 25; 21; 23). In all, baby formula basically contained closer constituents to the human breast milk.

The results showed that the importance of breastfeeding cannot be overemphasized as the composition of carbohydrate is high enough for brain development. The minerals needed are in the right proportions for the child. The content of human breast milk is also constantly changing as it is affected by consumption of a wide range of food to accommodate the baby's growing need.

Whole cow milk does not contain sufficient vitamin E, iron or essential fatty acids, which can meet infants need. Infants, when Fed on cow milk can cause anemic. Whole cow milk also contains excessive protein, sodium and potassium which may put a strain on the infant's immature kidneys. The proteins and fats in whole cow milk are more difficult for an infant to digest and absorbed than the ones in breast milk (20; 21). A significant minority of infants are allergic to one or more of the constituents of cow milk, most often the high amounts of lactose and agglutinin. These problems can also affect infant formulas derived from cow milk.

Table 1: chemical composition of human breast milk, cow milk, goat milk and baby formula

	Protein	Fat	Ash	Moisture	Carbohydrate
Human breast milk	1.67±0.02	4.19 ± 0.01	0.27 ± 0.02	86.63 ± 0.02	7.24 ± 0.03

Vol. 4, No. 01; 2019

ISSN: 2456-8643

Cow milk	3.51 ± 0.03	4.51 ± 0.02	0.66 ± 0.01	87.00 ± 0.01	4.65 ± 0.02
Goat milk	3.37 ± 0.02	4.86 ± 0.02	0.87 ± 0.02	88.55 ± 0.02	2.29 ± 0.02
Baby formula	1.77 ± 0.02	4.13 ± 0.02	0.18 ± 0.01	85.37 ± 0.02	5.21 ± 0.02

Goat milk does not contain agglutinin which means that fat globules in goat milk do not cluster together like they do in cow milk which makes goat easier to digest. Goat milk also does not contain most of the allergens found in cow milk (15; 26). However, like cow milk, goat milk is also unstable for infants to digest as it does not have appropriate concentrations of electrolytes and can cause intestinal irritation and anemia. Human milk is noticeably thinner and sweeter than cow milk.

Table 2: minerals composition of human breast milk, cow milk, and goat milk and baby formula

	Calcium (Ca)	Iron (Fe)	Zinc (Zn)	Magnesium (Mg)
Human breast milk	33.39 ± 0.70	0.05 ± 0.01	0.18 ± 0.02	3.61 ± 0.13
Cow milk	119.60 ± 0.71	0.07 ± 0.02	0.38 ± 0.01	13.44 ± 0.22
Goat milk	131.26 ± 0.11	0.06 ± 0.00	0.33 ± 0.03	13.94 ± 0.11
Baby formula	105.15 ± 1.12	0.055± 0.01	0.29 ± 0.01	9.41 ± 0.01

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REFERENCES

(1) Haenlein G F W. (1992): Role of goat meat and milk in human nutrition. Proceedings Vth International Conference on Goats, New Delhi, India, March 1-8, ICAR Publ., New Delhi, 2 (II): 575-580.

(2) Park Y W. (1991): Relative buffering capacity of goat milk, cow milk, soy-based infant formulae and commercial nonprescription antacid drugs. J. Dairy Sci. 74:3326-3333

(3) Lothe L., Lindberg T and Jacobson I. (1982). Cow's milk formula as a cause of infantile colic. A double-blind study Pediatrics, 70: 7-10.

Vol. 4, No. 01; 2019

ISSN: 2456-8643

(4) Host A, Husby S and Osterballe O. (1988). A prospective study of cow's milk allergy in exclusively breast-fed infants. Acta Paediatr. Scand. 77: 663-670.

(5) Ambrosoli R., Stasio L di and Mazzocco P. (1998): Content of alpha-s-1-casein and coagulation properties in goat milk. J. Dairy Sci,: 71: 24-28

(6) Jenness R. (1980): Composition and characteristics of goat milk: Review 1968-1979. J. Dairy Sci. 63:1605-1630.

(7) Bates C J and Prentice A. (1994): Breast milk as a source of vitamins, essential minerals and trace elements. Pharmacol Ther.; 62(1-2): 193-220.

(8) AOAC (1990). Official Methods of Analysis 4th Edition, Association of Official Analytical Chemist, Washington DC

(9) James, C.S. (1995). Analytical Chemistry of Food. Champman and Hall, London, PP:64

(10) Udo,E.J and Oguwele, J.A. (1986). Laboratory Manual for the analysis of soil, plants and water samples. 3rd Edition, department of crop production, university of Ilorin, Kwara State, Nigeria. pp:131-152

(11) WHO/FAO report. (1996): Trace elements in Human nutrition and health.

(12) Posati L P and Orr M L. (1976) : Composition of Foods. Dairy and Egg Products. USDA-ARS. Consumer and Food

(13) Miller GD., Jarvis J K., and McBean LD.(1999) : Handbook of Dairy foods and Nutrition.2 ndEd. Edited by lra Wolinsky.

(14) Alichanidis E, Polychroniadou A. (1996): Special features of dairy products from ewe and goat milk from the physicochemical and organoleptic point of view. In: Proceedings, Production and Utilization of Ewe and Goat Milk, Crete, Greece, Oct. 19-21, 1995, International Dairy Federation Publ., Brussels, Belgium, p. 21-43.

(15) Hachelaf W., Boukhrelda M., Benbouabdellah M., Coquin P., Desjeux J F., Boudraa G and Touhami M. (1993): Comparative digestibility of goat versus cow's milk fats in children with digestive malnutrition. Lait 73:593-599.

(16) Gorban A M S and Izzeldin O M (1997): Mineral content of camel milk and colostrum, J. Dairy Sci. 64: 471-474.

(17) Casey C E and Hambidge K M. (1983): Nutritional aspects of human lactation. In: MC Neville, MR Neifert (eds.), Lactation: physiology, nutrition and breastfeeding. New York: Plenum, p: 203-204.

Vol. 4, No. 01; 2019

ISSN: 2456-8643

(18) Fomon S J. (1993): Nutritional requirements in relation to growth. Monatsschr Kinderheilkd,; 122: suppl: 236-239.

(19) Krebs N F and Hambique K M. (1985). The effects of dietary Zn supplement during lactation. Amr. J. Clin. Nutrition; 41: 560-570.

(20) Ogbu ISI (2003) : The biochemical composition of the breast milk of Nigerian mothers. Mary Slessor J of Medicine Vol.3 (1): 1-4.

(21) Slusser W and Powers N G (1997): Breastfeeding update 1: immunology, nutrition, and advocacy. Pediatrics in Review.; 18(4): 111-119. the seminar organized by Kensington Pharmaceuticals Nig. Ltd.,Lagos on August 21, 2003.

(22) Hamosh M. (1992): Human milk composition and the function in the infant. Seminars in Pediatric Gastroenterology and Nutrition.; 3(3): 4-8.

(23) Lawrence R A and Lawrence R M. (2005): Breastfeeding, A Guide for the Medical Profession, 6th Ed. Elsevier Mosby, Phila.; p73-86, p105-214.

(24) Desjeux J F. 1993. Nutritional value of goat milk. Lait 73:573-580.

(25) Bindal M P and Wadhwa B K. (1993): Compositional differences between goat milk fat and that of cows and buffaloes. Small Rumin. Res. 12:79-88.

(26) McGee, Harold (2004) on food and cooking: The science and lore of the kitchen, completely revised and update. New York, NY: Scribner pp 13 ISBN 978068400011