Physicochemical Characteristics of Goat's Milk

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Abstract: As goat's milk has many therapeutic properties and nutritive value, various investigators studied its chemical composition and physical characteristics; where these compositional changes, may alter the processing quality of goat's milk. So, this study aware with some physiochemical properties of goats milk as a functional diet for human health.

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Introduction

Since ancient times, goat animal has been exploited for its milk. The production of goats milk (caprine) is major importance in several countries where climatic conditions are not favorable for cattle keeping (Juarez and Ramos, 1984). In 1981, world goat's milk production was 7236 tons contributed only 1.6% to all world milk production and ranked the fourth after cows (91.2%), buffaloes (5.6%) and ewes (1.9%) milk (Le-Jaouen 1981). However, world production of goat's milk reached in 1994 approx. 8 million tons/year (Dostalova, 1994). In 1997, Le-Pape *et al.*, stated that consumption of goats milk and goats cheese was increasing most rapidly in Northern European countries, thus was attributed to consumer mistrust of cow like products after the BSE scare. In Egypt, the total population of goat animals is approx. 3198000 produced about 13000 tons of milk, (Egyptian Central Organization 1996),however a growing interest with respect to production and utilization of goats milk is recently observed.

Dairy product goat and sheep farming are a vital part of the national economy in many countries, especially in the Mediterranean and Middle East region and are particularly well organized in France, Italy, Spain and Greece (Chiafalo *et al.*, 2004) presently, India possesses 126 million goats which contribute 14.5% of the world (FAO, 2009).

Goats milk, as all other milks, contains various nutrients either as major components or as macro and micro components. It's considered as an ancient product for the diet of today. Jenness (1980) recorded that goats milk is approx. isocaloric as cows and buffalo's milk each furnishes about 750 Kcal/l.

In 1981, Le-Jaouen reported that goat's milk has similar vitamins contents of human milk except lower content of folic acid, Vit. C and Inositol. He added that goats butter is reputed to been effective remedy against disease such as rheumatism and arthritis.

Goat's milk contains vitamins, minerals, trace elements, electrolytes, enzymes, proteins, and fatty acids that are easily assimilated by the body. Goat's milk has a similarity to human milk that is unmatched in cow milk and also has several medicinal values. Therefore awareness about advantage of consumption of goats milk should be popularized so that production and utilization of goat's milk could be enhanced (Kumar *et al*., 2012).

Goats milk shows therapeutic virtues for individuals with certain dietetic problems, thus physicians have traditionally recommended goats milk for infant and others allergic to cow milk. Similarly it has been used in treatment of ulcers (Mereado, 1982, Kumar *et al.*, 2012).

Superiority of goats milk is due to better fat and protein digestibility and assimilation; to its significantly higher minerals & vitamins composition and to incidence of allergy is lower (Bielak 1993; and Dostalova, 1994, Belewu *et al.*, 2002).

As goat's milk has these therapeutic properties and nutritive value, many investigators studied its chemical composition and physical characteristics where these compositional changes, may alter the processing quality of goats milk.

Some Factors affecting the composition of goat's milk

Composition of goat's milk widely differs according to many various factors. The three main effective factors are breeds (indigenous or selected breeds), stage of lactation, feeding or rations components.

a) Breed influence

Origin and type of bread markedly affected milk yield and composition. It is necessary to distinguished between two types of goats milk, the first (which is the more common) is produced from indigenous breeds which have a low average milk yield but have a high total solid. The second type is

produced by highly selected breeds with high yield but with a lower total solid (Atinsoyinu *et al.*, 1977, El Zayat *et al.*,1984, Kalantzopoulos 1993). The mean gross composition of goats milk produced from different breeds in different countries was summarized in Table (1).

Helmut and Fiechter (2012) studied the chemical composition and physical properties of goat's milk species in Austria. Thus, milk samples of six dairy goat breeds in Austria (Bunte Deutsche Edelziege, Pinzganer Ziege, Saanenziege, Strahlenziege, Toggenburger Ziege, WeiBe Deutsche Edelziege) were analysed for physicochemical characteristics for 8 months from March to October. Considerable seasonal variations, but nearly no statistically significant differences between milk samples from these six goat breeds were observed regarding most parameters.

b) Stage of lactation

Stage of goat lactation is markedly affected the resultant milk either yield or composition. Csapo-Janos *et al*. (1984) reported that TS, casein and NPN contents are gradually increased throughout lactation period while TP and WP fluctuated and then increased sharply at the end of lactation period. However, in (1985), Garefa *et al*. showed that fat content decreased during milking period from 5.96 to 4.76% and protein increased from 3.30 to 3.75%. Brown *et al*., (1995) stated that relative amount of α_{s2}-CN decreased with stage of lactation, also relative amount of K-CN increased by 50% after peak lactation and its concentration. Almost doubled near the end of lactation. Kracmar *et al*. (1998) studied the change in amino acids composition of goat's milk during lactation period from 5th to 33rd days in White Short Wooled goats. They concluded that: (a) decrease in non-essential amino acids was ranged from 0.39 to 10.05; (b) decrease in essential amino acids was ranged from 0.79 to 41.6%; (c) Threonine and Iso-leucine was decreased sharply (d) All other amino acids widely decreased.

Bhosale *et al*. (2009) indicated that lactation had significant increasing effect on fat, protein, ash, TS, SNF, titratable acidity and viscosity. All milk components are gradually increased from I to IV lactation with exception of lactose and pH.

Hejtmankova *et al*. (2012) studied the changes in composition of whey protein of Czech white short-haired goat throughout the lactation period and found that at the end of the lactation period the content of β-lg increased steeply, and the β-Lg/α-La ratio reached a maximum value of 1.94% in goat milk. In addition, goat milk contains a similar amino acids profile to ewe milk but the amino acid pattern in whey protein differs from that in milk.

Table (1) : Mean composition of goat's milk produced form different breeds in various countries.

Country	Breed	%					References
		Total solids	Fat	Protein	Lactose	Ash	
Germany	Improve fawn	12.43	3.92	2.9	4.01	-	Graf *et al.* (1970)
Nigeria	Saanen	12.15	3.41	3.07	4.54	-	Mba *et al.* (1975)
Nigeria	African Dwarf	18.68	6.90	3.91	6.30	0.82	Akinsoyinu *et al.* (1977)
Australia	Saanen	13.47	4.61	3.39	4.93	-	Ranawana & Kellaway (1977)
USA	Pygmy	21.55	7.76	4.71	5.58	-	Jenness (1980)
Egypt	Breed in Sinai peninsula	12.91	4.04	3.35	4.48	0.84	El-Zayat *et al.* (1984)
Iraq	Native	13.39	3.42	3.76	5.3	0.83	Ali and Hassan (1988)
Egypt	Baladi	12.33	4.06	2.92	3.88	0.80	El-Alamy *et al.* (1990)
Greece	____	11.76	3.44	3.35	4.30	0.79	Voutsinas *et al.* (1992)
Saudi Arabia	Masri	--	3.06	3.41	4.51	0.77±0.7	Sawaya *et al.* (1994)
Poland	Improved white breed	--	4.1	2.9	--	0.80	Szymanowska & Lipecka (1997)

c) Feeding.

Ration is the main factor affects milk composition as it is the source of milk constituents, and controls the fermentation process in rumen. For example, El-Alamy *et al*. (1987) reported that goats fed on concentrate and roughage ration of 70: 30 gave significantly higher fat and TS contents. However, Kholif and Abou-El-Nor (1998) studied the effect of replacing corn with powder Date seeds in diets of Baladi lactating goat's on their productive performance during the 1st week of lactation. They reported that Fat, TS, TP as well as total saturated, short and medium chain fatty acids contents tended to be higher, while lactose content and C_{15}, C_{16} total unsaturated fatty acids were decreased. Morsy, *et al*. (2012) concluded that supplementing Anise oil, Clove oil or Juniper oil for lactating goats improve rumen fermentation as propionate production and

reduce acetate proportion and improved milk protein of lactating goats. Juniper oil supplementation improved conjugated linoleic and omega 3 fatty acids in milk fat. Juniper oil supplementation to dairy animals can contribute to improve the health properties of milk.

Main chemical composition of goat's milk

1- Milk proteins

Generally, two main groups of milk protein are distinguished; namely casein micelles and whey protein. Five principal proteins of goats milk closely resemble their homolog's in cow's milk are α_{s2}-CN, β-CN, K-CN, β-lg and α-La (Jenn ess 1980). He showed that goat's milk lacks homolog of bovine α_{s1}-CN, the most abundant protein in cows milk. Distribution of amino acids composition of isolated goat milk proteins is showed in Table (2) as reported by Christrian (1996).

Jooyandeh and Aberoumand (2010) showed that non protein nitrogen (NPN) content of goat and human milk are higher than in cow milk while Hejtmankova *et al.* (2012) concluded that total essential amino acids were approximately 40% of the total amino acids in goat and ewe milk as well as in goat and ewe whey.

2- Casein micelles

Casein is the main protein fraction in all milks which represents approx. 80% of the total protein. The most significant aspect of the structure of milk casein is the fact that α-CN, β-CN and calcium phosphate are located in the interior of the micelles, whereas K-CN is predominantly located on the surface of the spherical casein micelle to form protective layer at the surface of each spherical micelle (Christrian 1996). The size of casein micelles varies considerably within and between species. They seem to be smaller in goats milk than in cow's milk. Peak frequency of micelle diameters of cows and goats milk was 75 and 50nm resp. (Le-Jaouen 1981).

Casein of goat milk was separated mainly into two groups. The faster group resembles α_S-CN from cows. The second with lower mobility resemble bovine β-CN plus K-casein; α_S-CN group included 2-3 zone and represented 37.25% of whole casein while β-CN included two components which represented 62.75% (El-Shibiny 1979). These data were confirmed lately by Hefinawy and Mehanna (1988); Mahran *et al.* (1988) and Abd-El-Salam (1992).

Goat casein fraction can be also subdivided into α_{S1}-CN, α_{S2}-CN, β-CN and K-CN, which occur as micelles complex in approx, proportion of 1.2.5.2 respectively being considered a β-CN rich and α_{S1}-CN poor (Remeuf and Lenior, 1985). However, Jaubert *et al.* (1997) recorded that this proportions are α_{S1}, α_{S2} β+γ-CN and K-CN were 10.4, 14.5, 62 and 13.2% in total casein.

Goat K-CN differs from its bovine counterpart in having a chain of 171 instead of 169 amino acid residue; Val and His being insert at position of 132 and 133. However, it likes bovine K-CN in having the same Phe. in position of 105 and Met. in position 106 (rennin action).

Another special characteristic of goats milk is higher level of polymorphism of α_{S1}-CN where clear differences in the levels of protein synthesized between alleles exist which correlates to composition of milk and with some milk processing parameters. It has been clearly demonstrated that genetic polymorphism in caprine α_{S1}-CN is strongly related to the casein content. Grosclaude *et al.* (1994) showed the existence of at least 14 alleles at α_{S1}-CN locus, distribution in 7 different classes of protein variants (A-G) associated with 4 levels of expression ranging between O (α_{S1}-CN null) and 3.6 gL^{-1} per allele (α_{S1}-CN A, B and C), with E as an intermediate variant (1.6 gL^{-1}). Variants A, B, C and E differ only by amino acid substitutions whereas variant D, F and G appear to be associated with a reduced α_{S1}-CN (0.6 gL^{-1}).

In (1998), Trujillo *et al.*, reported that 3 variants are associated with high α_{S1}-content in goat milk (A, B, C); 1 to an intermediate content (E); 3 to a low content (D, F, G) and 1 to a null content.

The most recent genomic data was recorded by Trujillo *et al.* (1997). They demonstrated that caprine casein present 8 different α_{S1}-CN genotypes (BB, BE, BF, BO, EE, EF, EO and FF) ordered from highest to lowest according to their theoretical protein content; and they differ in their mobility in alkaline urea PAGE.

Chianese *et al.* (1997) detected three noval α_{S1}-CN variants H, I, L in caprine milk from Italian breeds. Iametti *et al.* (1997) recorded that genetic variants of α_{S1}-CN have different isoelectric points pH. (A) 3.87-3.76; B) 3.72-3.60; (F) 4.01-3.95.

A relationship between the occurrence of polymorphic forms of α_{S1}-CN and physico-chemical properties of milk is emphasized, this relation affected caprine milk processing quality (Mahaut and Korolezuk 1994; Tziboula 1997 and Mahmoud& Usman 2010).

Goat's milk that lacked α_{S1}-CN had lower percentages of milk components and poorer coagulation properties than milk that contained α_{S1}-CN, suggesting that the presence of α_{S1}-CN in milk should improve coagulation properties (Clark and Sherbon, 2000).

3- Whey proteins (WP)

Goat whey proteins were separated to 5 fractions. They are β-lg (presented 60% to total WP), α-la, serum albumin, immunoglobin and protease

peptones (El-Shibiny 1979 and Mahran *et al.*, 1988). Kalantzopoulos (1993) stated that goats' milk contains four times less α-la, three times less serum albumin but more β-lg than cows homologs.

Goat β-lg like its bovine homolog consists of a polypeptide chain of 162 amino acid residues but differs from bovine β-lg at six positions.

On the other side, α-la of bovine and goats milk is differed in their amino acid sequence. There are 12 differences between goat α la-B (the common variant in cattle of European origin) in the chain of 123 residues (Jenness, 1980).

Goats milk content 2.75% total protein, 0.433 (g/100 g) whey proteins and 0.119 (g/100g) β Lg/ the continents of total protein as well as acid whey protein nearly constant throughout the lactation period; the average ratio of whey total protein was 15.8±2.61% in goat milk Hejtmankova *et al.* (2012).

Table(2): Amino acid composition of isolated goat's milk proteins (mg/100g).

Amino acid	α_{S2}-Casein	β-Casein	K-Casein	β-Lacto-globulin	α-lactal-bumin
Alanine	10	5	16	16	5
Arginine	6	3	5	3	1
Aspartic acid	17	9	16	14	22
Cysteine	2	0	3	5	8
Glutamic acid	45	43	26	24	13
Glycine	4	6	1	5	5
Histidine	5	5	4	2	3
Isoleucine	11	9	11	10	8
Leucine	12	20	8	21	13
Lysine	22	12	8	16	13
Methionine	4	6	1	4	0
Phenylalanine	8	9	4	4	4
Proline	18	33	19	8	2
Serine	14	15	13	6	6
Threonine	14	12	15	8	6
Tryptophan	2	1	1	2	4
Tyrosine	11	4	9	4	4
Valine	12	21	11	10	6
Total	217	213	171	162	123

Kalantzopoulos (1993) showed an Electrophoretic pattern of cows, sheep's and goats casein (Fig. 1).

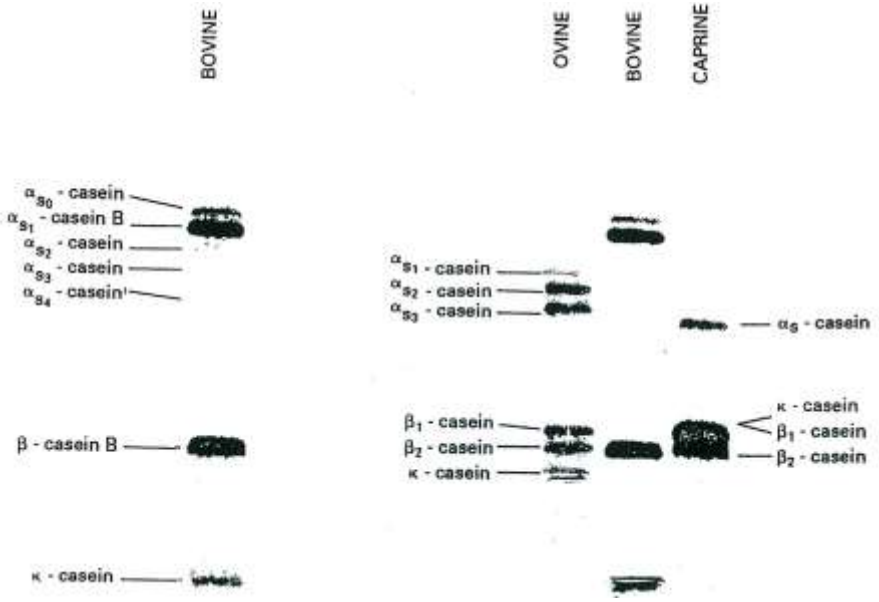

Fig. (1). Electrophoretic pattern of bovine, ovine and caprine casein on polyacrylamide gel

4- Minor proteins

Goats milk, like cows milk, contain 20 to 200 ug/ml each of lactoferrin and transferring, while contains a mean prolactin conc. Of 44±5 ug/ml (cow milk contained 60 ± 2ug/ml). Goats milk contains approx. 12 ug/ml of folate-binding protein, it contains also greatest level of immunoglobulin's which resemble 30-50 ug of Ig_A; 10-40 ug of Ig_B and 100-400 ug of Ig_G ml in mature milk (Jenness 1980 and Shimzaki *et al.*, 1991 and Helemet and Fiechler, 2012).

5- Milk lipids

Fat is composed essentially of glycerides and steroids (99%). The fat forms globules which are suspended in milk as an emulsion.

Fat globules of goats milk resemble those of cows milk in lipids composition and properties of the globule membrane but goats milk lacks agglutinin (Jenness 1980). Average total lipids content was about 5±1.2% for goats' milk; whole milk contains 97% free lipids and 1% bound lipids. Free lipids were 96.8% triglycerides. In this respect, goat milk resembles cows milk, however contained significantly more free lipids than did for cows milk (Cerbulis *et al.*, 1982).

Triglyceride (TG) composition is also differed in goats and cows milk (Fig. 2) where these were 16 peaks corresponding to TG of 24 to 54 carbon atoms. In cow milk there were clear maxima, located at C_{38} and C_{50-52} (12.8 and 12.0% respect. average values).Whereas in goats milk, the TG content increased with the number of carbon atoms reaching maximum (13%) at C_{40} and C_{42}. The largest relative differences between goat and cow milk fat were found in TG C_{42}, C_{44}, C_{50}, C_{52} and C_{54} (Forntecha *et al.*, 1998).

The average diameter of globules in goats milk is about 1.5-2 um compared to 2.5-3.5 um for cows milk and the percentage of globules of less than 1.5 um is 28% for goats milk vs 10% for cows milk (Le-Jaouen, 1981 and Kalantzopoulos, 1993). Fat globule membrane protein of goats milk has 1.64% sialic acid, 3.28% hexos, 2.83% hexoamin and 0.17% phosphorus which were similar for cows and buffaloes milk (Singh *et al.*, 1977).

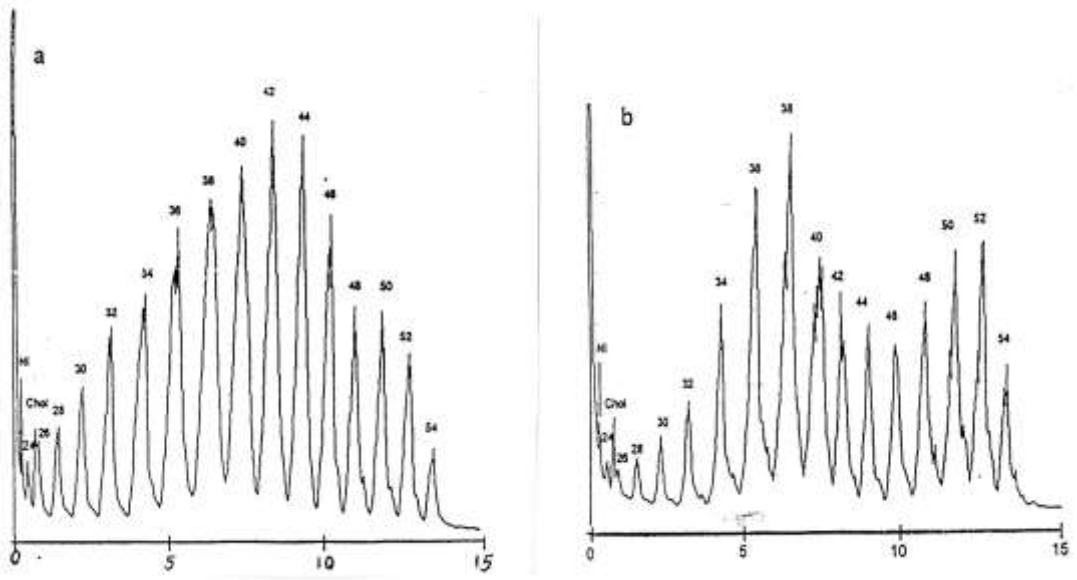

Fig. (2). Gas chromatographic profiles of triglycerides of a goat milk fat sample (a) and of the reference cow milk fat (b), using short capillary column.

Fat has largely the same composition of fatty acid as in cow's milk, however the proportions are different. It is rich in short chain fatty acids (C_4 to C_{10}) which represent 15% of all fatty acids (Le Jaouen, 1981). There are three fatty acids higher (two fold) in goats milk than cows milk; C_8, C_{10}, C_{12} (Juarez and Ramos, 1984).

Fatty acids composition of goats milk reported by various authors and compared with those of cows milk is summarized in Table (3).

Chilliard and Freund (1997) summarized the characteristics of goats milk lipids compared with cows and human milks as follows.

1) Goat's milk has higher fat contents than cows and human milk.

2) It has a higher content of small fat globules and does not contain agglutinin.
3) It has low tochopherol and carotene contents.
4) It has a higher content of C_8, C_{10}, C_{12} fatty acids.
5) Lipoprotein lipase activity is lower in goat's milk than cow's milk but in goat milk this activity is more closely bound to the fat globules and highly correlated with lipolysis.

Indratiningsih, *et al.* (2012) showed that fermentation process increased conjugated linoleic acid (CLA) content of goat milk from 3.09mg/g fat in fresh milk to 3.26 mg/g fat in fermented.

6- Lactose

Lactose is the main constituent of the dry matter of milk. It is reducing carbohydrate and it is present in its liquid phase. Lactose of goat's milk does not differ from that of cows milk but its content varies very little during lactation period (Le-Jaouen, 1981). Bhosale *et al.* (2009) indicated that the lactation had significant increasing effect on lactose.

Helmut and Fiechter (2012) showed that goats milk contain about 4.23% lactose. This data obtained from six dairy goats breeds in Austria. No recent further data are available for the lactose content of goat's milk.

7- Minerals and trace elements

Mineral composition can be used recently to distinguish or identify of animal origin of raw milk; cows milk on one hand and goats & ewes milk on the other (Rincon *et al.*, 1994).

Levels of some minerals and trace elements in goats and cows milk were determined by various authors as mentioned by Jenness (1980) Tables (4) & (5).

Table (3): Fatty acids composition percent of goat's milk reported by different authors and compared with those of cows milk.

Acid	Goats milk					Cows milk
	Garcia *et al.*, **1979**	**Boccignone** *et al.*, **1981**	**Sawaya** *et al.*, **1994**	**Martin Hernandez** *et al.*, **1986**	**Hellin** *et al.*, **1998**	**Martinez-Castro** *et al.*, **1979**
$C_{4.0}$	2.3	1.81	3.0	1.8-2.8	3	2.5-6.2
$C_{6.0}$	2.7	2.03	2.0	2.2-3.4	6.3	1.5-3.8
$C_{8.0}$	3.2	2.68	2.0	2.4-3.9	2.9	1.0-1.9
$C_{10.0}$	11.5	8.45	6.1	8.8-13.4	10.4	2.1-4.0
$C_{12.0}$	5.3	5.21	2.9	3.8-5.5	5.6	2.3-4.7
$C_{14.0}$	10.4	10.52	9.5	8.5-11.6	12.8	8.5-12.8
$C_{14.}1$	-	00.96	0.4	0.5-0.8	-	0.6-1.5
$C_{16.0}$	24.9	24.33	28.6	23.3-32.1	34.8	24.0-33.3
$C_{16.1}$	-	2.58	2.5	1.0-2.0	-	1.3-2.8
$C_{18.0}$	9.7	9.49	10.3	4.3-11.2	6.8	6.2-13.6
$C_{18.1}$	21.6	23.96	26.3	16.2-26.6	13.3	19.7-31.2
$C_{18.2}$	1.6	1.68	2.6	1.2-2.5	3.9	1.3-5.2
$C_{18.3}$	1.2	-	-	0	0.9	-

Table (4): Trace mineral content of goat's milk.

Country	Breed	Time postpartum	Animals	Samples	Fe	Cu	Mn	Zn	1
					-------	(mg per liter)		-----	(μg/liter)
Nigeria	Dwarf	1-5 days	10	5	2.46	3.14	.20	14.11	319.7
		2-18 weeks	10	17	.43	.28	.05	4.01	108.5
Egypt	?	?	26	26	.56	.13	.19	1.92	
Greece	?	?		56					2.2
Japan	?	4-5 mo	2	2	.65	.29			

Table (5): Principal minerals and citrate in goat's milk.

Country	Animals		Sample no.	Na	K	Ca	Mg	P	Cl	Citrate
	Breed	No.								
							(mg/100ml)			
Eire	?	9	9			151		86[a]		
Egypt	?	?	50			136		61[b]	172	
England	Saanen-Welsh	14	11-23	44	180				153	98
	Saanen	4	4							ca 150
	Saanen	1	4							ca 180
	Sanen-Toggenburg	6	31	40	241				136	70[c]
Iran	?	4	?				11.5			
Japan	?	2	2	51	212	137	14.5	106	161	
	Toggenburg	2	31	41	190	133	36[d]	116	121	
Philippines	Saanen	11	?			139		121		
Trinidad	British-Alpine		16	53	164	85[c]	13	75[d]		
	Anglo-Nubian		16	56	153	90[c]	10	82[d]		
USA	?		1	39	242				202	
	Pygmy	6	6			198		153		139
	Four breeds[e]		24		170	137	17	112		
	?		4	38	193	138	21	95	204	151
Yugoslavia	Composite		3			123		98		
Scotland	Ayshire (Cow) Bulk		12	58	140	118	12	95	104	176

[a] Inorganice P (Pi). [b]Probably inorganic P (Pi) only. [c]Seems very low.
[d]seems very high. [e]French Alphine, Nubian, Saanen and Toggenburg.

Distribution of Ca, Mn and P in goats' milk between colloidal and dissolved state were very similar to those of cow and buffaloes milks in Egypt. breed (Ahmed 1979). The distributions were total Ca (131.68 mg/100 ml), soluble Ca (36.70 mg/100 ml); total Mn (8.4 mg/100 ml); soluble Mn (2.2 mg/100ml); total P (44.83 mg/100ml) and soluble P (30.11 mg/100ml).

Level of other trace elements was also determined by Middleton and Fitz-Gerald (1981) as listed in table (6). They concluded that goats' milk is higher in Cu but lower in Fe and Cd.

Table (6): Some trace elements in goat's milk compared with cows milk

Trace elements mg/L	Goats milk	Cows milk
Cd	0.002	0.006
Cr	0.013	0.016
Cu	0.287	0.194
Fe	0.427	0.730
Pb	0.035	0.039
Ni	0.01	0.01
Zn	4.756	4.275

El-Alamy *et al.* (1990) determined also trace elements and minerals of Egyptian Baladi goat's milk. They mentioned that, K (142 mg/100 ml), Cl (148 mg/100ml) and Mg (22.3 mg/ml) contents were also higher than cow's milk.

Gueguen and Freund (1997) reviewed the mineral composition of goats' milk in France. They concluded that it is similar to that of cows milk but it has higher contents of K, Cl and Mg (1900, 1600 and 130 mg/kg) for goats milk vs. (1500, 110, 110 mg/kg) for cows milk. They added that goats milk has content of P is 2-3 x higher than that of human milk and its Ca. P ratio is great deal lower than that of human milk.

Urbriene *et al.* (1997) recorded that human and goats milk have similar content of some microelements except Fe which is 1.8-2 x higher in human milk, while the concentration of macro elements is similar in goats and cows while concentration of K, Ca and Mg were widely varied. In (1998), Gue *et al.*, reported also that ration of Na: K (which represented 1: 3) is the main reason for lower alcoholic stability of goats milk.

Belewu, and Aiyegbusi (2002) reported that, the milk of goat (West African dwarf) which contained more mineral contents similar to that of human milk, is pointer to the nutritional contribution of goat milk in a country like Nigeria prevailing undernourishment and malnutrition are accompanied by low intake of some minerals and vitamins among the populace and most especially Vulnerable (Pregnant, Lactating mothers, infants and weanlings and the sick) groups.

Guzeler *et al.* (2010) showed that, results of the statistical analyses indicated significant lactational effects on total solids, fat, non-dry matter, protein, lactose, energy value, titratable acidity, pH, specific gravity (P<0.01) and sodium (P<0.05), but

there was no similar effect on the contents of calcium, phosphorus, magnesium and potassium values of goat's milk ($P < 0.05$).

8- Miscellaneous.

- **Vitamins**

Vitamins content of goats milk varies with season, feeding and other factors. Le-Jaouen (1981) listed vitamin content of goats, cows and human milks (Table 7). He demonstrated that goats' milk has similar content of vitamins as human milk with exception of a lower content of folic acid, vit. C and Inositol. He added that goats' milk contains less vit. B_6 and B_{12} than cows milk but this does not present nutritional problems. This data were confirmed also by Kalantzopoulos (1993).

Table (7): Vitamins content of milk in different species.

	Goat	Cow	Human
Vitamin A (IU/100 ml)	191	159	190
Vitamin B-1 (Thiamin)	0.04	0.04	0.02
Vitamin B-2 (Riboflavin)	0.18	0.17	0.04
Niacin	0.19	0.09	0.15
Vitamin B-6	0.01	0.06	0.01
Pantothenic acid	0.34	0.34	0.18
Biotin	0.004	0.003	0.001
Folacin	0.0008	0.0059	0.0038
Vitamin B-12	0.00007	0.00042	0.00003
Vitamin C	1.5	2.1	4.3
Vitamin D (IU/100 ml)	2.4	2.2	2.2
Vitamin E	?	0.10	0.65
Other factors			
Choline	15.0	13.7	9.0
Inositol	21.0	11.0	33.0

(mg/100 ml unless otherwise indicated)

In (1997) Jaubert and Freund summarized the differences in vitamins content between goats, cows and human milks as follows.

1) Goats and cows milks have similar content of Vit A and C < human milk.
2) Goats milk has lower content of Vit. E than human milk.
3) Goats and human milk have similar content of Vit. B_{12}.
4) Goats milk has higher content of Vit B-group (B_1, B_2, B_3, B_5, B_6 and B_8) than human milk.
5) Vit. D contents are similar in the three milks.

- **Enzymes.**

Goats milk has lower activities of certain enzyme, e.g. ribonuclase, alkaline phosphatase, lipase and xanthin oxidase than bovine milk. In contrast to bovine milk, lipase activity in goats milk significantly correlated with spontaneous lipolysis probably due to the particularities of the lipolysis system and plays a major in off-flavour development in milk (Jenness, 1980 and Kalantzopoulos, 1993).

Some physical properties of goat's milk.

Little studies were done for estimating the physical properties of goat's milk. So some miscellaneous physical properties were focused here.

Viscosity of Egyptian goats milk was 2.385 CP recorded by(El-Zayat *et al.* ,1984) and 1.520 for Indian goats milk recorded by(Majee *et al.*,1994) against 1.230 for cow's milk (O'Connar and Fox, 1979).Natural acidity of goats milk is slightly lower(0.16%, El-Alamy *et al.*,1990) vs. 0.17-0.18% for cows' milk (Le-Jaouen, 1981).

Goats' milk has less alcoholic stability when compared with cows milk where it precipitates on addition of 44% ethanol vs. 70% for cows milk (El-Zayat *et al.*, 1984 and Gue *et al.*,1998). It has freezing point slightly higher than cows milk equal -0.543°C (Alkanhal 1993) vs.-0.564°C for cows one (Linzell, 1967). However, its specific gravity ranged between 1.0263 to 1.0335 vs. 0.1320 for cows milk (Ali and Hassan 1988, Voutsinas *et al.*1992, Hamed *et al.*1993 and Majee *et al.*1994, Mahmood and Usman (, 2010).

Helmut and Fiechter (2012) showed that the mean values obtained for all breeds of goats in Austria during the whole season were as follows: pH 6.55, freezing point depression -0.549°C. Jooyandeh and Aberoumand (2010) showed that lipids in sheep and goats milk have different physical characteristics than cow milk.

Conclusion

Goat's milk, as all other milks, contains various nutrients either as major components or as macro and micro components. It considered as an ancient product for the diet of today. Several tries were made to utilize goat's milk in manufacture of various dairy products.

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