TOPIC 2. CHEMICAL CHARACTERISTICS

The chemical composition of an animal is an important consideration when determining nutrient requirements, since requirements are equal to the sum of nutrients deposted plus the nutrients necessary for metabolism but not incorporated into body tissue. If, for example, each kg of fat in a ruminant's body has an energy content of 9000 kcal kg^{-1}, then at least 9000 kcal of energy were ingested chemically in a kg of tissue. Since the deposition of fat or any other tissue is not a 100% efficient process, the energy required to deposit a kg of fat with an energy content of 9000 kcal is 9000 plus the energy for nutrient metabolism. The energy required for this deposition is analogous to overhead, or operating costs in a business.

Some of the tissue energy, especially fat, serves as a reservoir of stored energy that may be critical for survival. Fat tissue can be almost totally depleted before death occurs, but other tissues, such as protein, cannot be mobilized to a large extent without causing weakness and deterioration of life functions. Some tissues, such as bones, contain minerals that may be mobilized for antler growth, and the amount of antler growth is dependent on the amount of minerals mobilized plus the amount ingested, within the framework of genetic limitations, of course. The former is indicative of the nutrient quality of the range over a time span of a year or more, the latter of the quality of the range during the period of antlerogenesis.

Chemical composition varies through the year in relation to growth and reproduction. It is a function of several variables through time, and may be expressed in relation to live or ingesta-free weight. Weight varies seasonally however; calculations of seasonal variations in chemical composition in relation to seasonally-variable weights result in estimates of the absolute quantities of different chemical components of the body.

The chemical composition of milk varies through lactation as the nutrient requirements of the suckling young change, and their diet includes relatively less milk and more forage as the rumen and reticulum develops. Changes in milk composition through the lactation period are not well documented in most species, nor are seasonal changes in overall body composition. The UNITS that follow provide some insights into the ecological roles of chemical changes, indicating the usefulness of this information in evaluating survival and production potentials.

UNIT 2.1: BODY COMPOSITION

Knowledge of the body composition of an animal is essential for understanding and predicting energy, protein, and mineral requirements for maintenance and growth. The net requirements for these three categories of nutrients are dependent on the energy content and composition of the tissue replaced and new tissue deposited. Relationships between chemical composition and nutrition in cattle were studied many years ago (See Reid et al. 1955), and general relationships between animal condition and visible fat have been observed for wild ruminants for years. Published data on the chemical composition of whole animals and on some body parts are available for domesstic ruminants. Few data are available on wild ruminants paper s on body composition have been more descriptive than quantitative, with emphases on "fat condition indexes" and similar approaches.

Fat tissue indices have been derived for some species of wild ruminants because they provide indications of the status of indiviuduals through the winter for general comparisons between ranges and between winters. Such indices are not useful for quantifying the metabolic contributions of stored fat for survival, however, and the expediency with which they may be determined should not replace basic investigations of the chemical composition of the body. Basic investigations result in the background knowledge and understanding necessary for quantifying animal-range relationships, resulting in better interpretation of condition indices based on fat and other tissue characteristics.

Fat. Fat is a high-energy reservoir--one gram of fat contains 9.0 to 9.5 calories of energy--that is mobilized when energy intake falls below energy requirements. It is necessary to know what metabolically-available quantities are present in the body throughout the year in order to analyze the ecological contributions of fat to seasonally-variable metabolic energy requirements. Then, weight changes and body composition can be combined to derive an equation for calculating the fat contribution to daily metabolism. This is done in Chapter 7.

Protein. The total energy content of an animal is equal to the actual amounts of protein and fat times the caloric values of each. The estimated caloric contents of body protein and fat were 5.413 and 9.490 kcal/g, respectively (Robbins et al. 1974). Protein tissue, while containing stored energy in the chemical bonds holding protein molecules together (about 5 calories per gram), cannot be mobilized to a large extent without the loss of body condition. When the fat reserve is gone and protein is catabolized to maintain the energy balance, the animal is in a very precarious state of existence. This is characteristic of animals that die in a long winter. Protein deficiencies may occur in the summer too; nursing females must supply a relatively large amount of protein via milk for their rapidly-growing offspring. Lactating wild ruminants are often quite thin, especially through the first half of the lactation period. The high protein requirement at that time should be mostly met by the high-quality forage on the range, but protein in maternal tissue may supplement that ingested in the forage.

Minerals. Minerals are essential components of most body tissue, and the major component of the skelton. The minerals that are a part of the whole body composition are not known for wild ruminants, however. Ash--the solid residue left after complete tissue combustion--has been measured for both domestic and wild species, but this general category does not reveal the amounts of specific minerals present or required. Feeding trials with various levels of different minerals in the diets are used to determine requirements, but interpretations of the results are often difficult to make because of interactions between minerals, and especially trace elements.

Water. There is a water component of living tissue that, for whole organisms, represents about 2/3 of the mass of most species. Water is a required nutrient that is "turned over," and thus needs to be replenished regularly. Some African species of wild ruminants have special adaptations for conserving water, with different physiological and behavioral adaptive strategies. North American ruminants are, for the most part, not particularly specialized in their use and conservation of water, and most species live in habitats that are not water-limited.

The amount of body water in adult ruminants is quite closely related to their fat content. Fat tissue contains only about 10% water, much less than the average of all body tissue, so as the adult ruminant puts on large quantities of fat in the fall, the water fraction goes down. Body composition of white-tailed deer show this clearly as fat and water were inversely related, with protein remaining fairly constant and ash being a minor component of the total body (Robbins et al. 1974).

The total body composition, expressed as decimal fractions, is:

$$FATF + WATF + PROF + ASHR = 1.00$$

where the ..F is fraction of the preceeding chemical group. This illustrates the fact that only four major chemical groups make up the body composition, yet there are few data even on these four major groups for wild ruminants.

The most ideal kind of data on chemical composition of wild ruminants would include variations due to sex, age, and time of year. Such data would provide the background material for interpreting the changes in weights and nutrient requirements over the annual cycle. Body composition analyses are being done on white-tailed deer at the Wildlife Ecology Laboratory, but results are not yet available.

LITERATURE CITED

Reid, J. T., G. H. Wellington, and H. D. Dunn. 1955. Some relationships among the major chemical components of the bovine body and their application to nutritional investigations. J. Dairy Sci. 38:1344.

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

REFERENCES, UNIT 2.1

BODY COMPOSITION

BOOKS

type	publ	city	page	anim	kewo	auth	year
edbo	acpr	nyny	1		mineral metabolism, vol. 2	comar,cl; bronner	1964
edbo	acpr	nyny			compar nutrit, wild animal	crawford,ma,ed	1968
aubo	nasc	wadc	19	anim	bdy comp in animls and man	reid,jt; bensado/	1968
edbo	erda	spva	536	odvi	min cyclng in se ecosystem	howell,fg; gentr/	1975
edbo	erda	spva	542	odvi	min cyclng in se ecosystem	howell,fg; gentr/	1975

SERIAL PUBLICATIONS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	49--8	1159	1162	cerv	composition adipose tissue	garton,ga; dunca/	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	38--4	871	876	odvi*	body composition, white-ta	robbins,ct; moen	1974
JWMAA	29--2	397	398	odvi	kidney, marrow fat, condit	ransom,ab	1965
JWMAA	29--4	717	723	odvi	naturl vari blood proteins	miller,wj; hauge/	1965
JWMAA	37--1	103	105	odvi	reag dry assay, marrow fat	verme,lj; holland	1973
JWMAA	39--2	346	354	odvi/chng	blood prot, gest, suc	hartsook,ew; whel	1975
NFGJA	21--1	67	72	odvi/riney	vs kidney fat techni	monson,ra; stone/	1974
NYCOA	3---5	19	22	odvi	bone marrw index of malnut	cheatum,el	1949
PAABA	600-1		50	odvi	nutri req, growth, ant dev	french,ce; mcewa/	1955
PAABA	628-1		21	odvi	nutri req, growth, ant dev	magruder,nd; fre/	1957
PCGFA	26---	57	68	odvi	var fat levl, mandib cavit	nichols,rg; pelt	1972
WSCBA	5---6	42	42	odvi	chemi anal of deer antlers	chaddock,tt	1940

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJVRA	31--4	673	677	odhe	total body water, turnover	longurst,wm; bak/	1970
JANSA	36--6	1201	1201	odhe	plasma prot, lipid lev,nev	hunter,ve; lespe/	1973
JOMAA	45--2	252	259	odhe	density studies, body fat	whicker,fw	1964

odhe continued on the next page

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	33--2	389	393	odhe	/water turnover in mule dee	knox,kl; nagy,jg/	1969
JWMAA	36--2	579	594	odhe	/indice, carc fat, colo pop	anderson,ae; me/	1972
JWMAA	41--1	81	86	odhe	exp starva, recovery, does	decalesta,ds; na/	1977
PCZOA	16---	46	46	odhe	chang, plasma lipids, th y	stewart,sf; nord/	1963
WAEBA	589--	1	6	odhe	the mule deer carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JSFAA	22--1	29	33	ceel	fatty-acid compos, adipose	garton,ga; dunca	1971
JWMAA	32--4	747	751	ceel	fat content, femur marrow	greer,kr	1968
JWMAA				ceel	milk comp and consump,capt	robbins,ct; podb/	inpr
MAMLA	35--3	369	383	ceel	demog,fat res,body size,nz	caughley,g	1971
WAEBA	594--	1	8	ceel	the elk carcass	field,ra; smith,/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AZOFA	12--2	148	155	alal	fatty-acid compos, org fat	tanhuanpaa,e; pul	1975
CBPAB	57--3	299	306	alal	/hair elemnt val,var, alask	franzmann,aw; fl/	1977
JWMAA	40--2	336	339	alal	marrow fat, mortali, alask	franzmann,aw; arn	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBCPA	30--1	187	191	rata	fatty acid comp bone marow	meng,ms; west,gc/	1969
CBPAB	55--2	187	193	rata	/serum enz, blood constitue	bjarghov,rs; fje/	1976
CBPAB	56--3	337	341	rata	liver, bone, bone marrow	bjarghov,rs; jac/	1977
CJZOA	50--1	107	116	rata	seas, body h2o, blood volu	cameron,rd; luic	1972
CJZOA	54--6	857	862	rata	tritium wat dilut wat flux	cameron,rd; whit/	1976
FUNAA	23	106	107	rata	fat deposits, svalbard dee	oritsland,na	1971
JWMAA	34--4	904	907	rata	wt, dried marrow,femur fat	neilans, ka	1970
NJZOA	24--4	407	417	rata	*morph, fat stor, org weigh	krog,j; wika,m; /	1976
PASCC	19---	17	18	rata	total body water, turnover	cameron,rd	1968
PASCC	22---	14	14	rata	water flux, climate, nutri	cameron,rd; luic/	1971
TNWSD	28---	91	108	rata	phys var, condit, b g cari	dauphine,tc,jr	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JANSA	33--1	309	309	anam	carbonyl analysis of fat	booren,a; field,/	1971
JANSA	36--6	1195	1195	anam	collagen character,muscle	kruggel,wg; field	1973
JDSCA	38---	1344	1344	anam	maj chem comp bovine	reid, jt; wellin/	1955
JOMAA	52--3	583	589	anam*	seas tren in fat lev, colo	bear,gd	1971
JWMAÂ	34--4	908	912	anam/	energy flux, water kinetic	wesley,de; knox,/	1970
WAEBA	575--	1	6	anam	pronghorn antelope carcass	field,ra; smith,/	1972

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	36--2	305	308	bibi	the lipids in bison bison	wilbur,dg; gorski	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
AJBSA	24--3	515	524	ovca	ovmu, sp diff hair protein	darskus,rl; gille	1971
BECTA	19--1	23	31	ovca	chlor hydrocarb resid, fat	turner,jc	1978

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBCPA	50b-4	599	601	ovda	fatty acid comp bone marrw	west,gc; shaw,dl	1975

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				obmo			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
				oram			

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	49--8	1159	1162	many	comp, adipose tiss triglyc	garton,ga; dunca/	1971
VEZOA	71--5	60	64	many	hyaluronic acid, synovi fl	kuprikova,vm	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
ATRLA	18-11	209	222	caca	drssng %, body comp, calor	weiner,j	1973

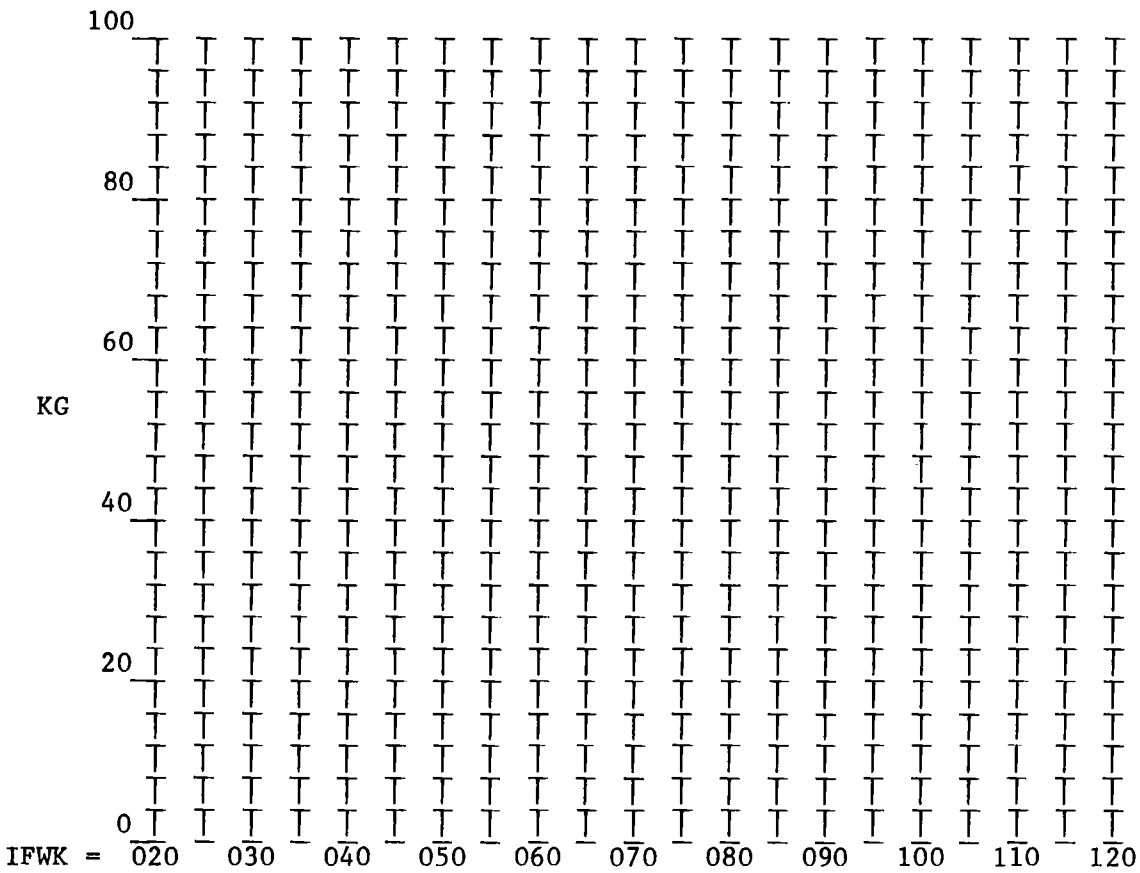
CHAPTER 2, WORKSHEET 2.1a

Body composition of white-tailed deer (odvi)

The body composition of white-tailed deer may be predicted from ingesta-free weight in kg (IFWK). Equations for males, females, and both sexes combined are given by Robbins et al. (1974). The sex differences are very slight when composition is expressed on a per kg basis. The equations for both sexes combined are:

$$WATK = e^{(0.8982 \ln IFWK - 0.0827)}$$
$$FATK = e^{(2.1345 \ln IFWK - 6.3944)}$$
$$PRTK = e^{(1.0091 \ln IFWK = 1.6267)}$$
$$ASHK = e^{(0.9480 \ln IFWK - 2.9008)}$$

Complete the calculations and plot the relationships below. Note that the sum of the weights should equal the ingesta-free weight used in the calculations; deviations are due to experimental error. What is the sum when weights characteristic of moose (500 kg) are used in the calculations? Are these equations realistic when extrapolated beyond deer weights?



LITERATURE CITED

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

CHAPTER 2, WORKSHEET 2.1b

Relative body compositions of wild ruminants

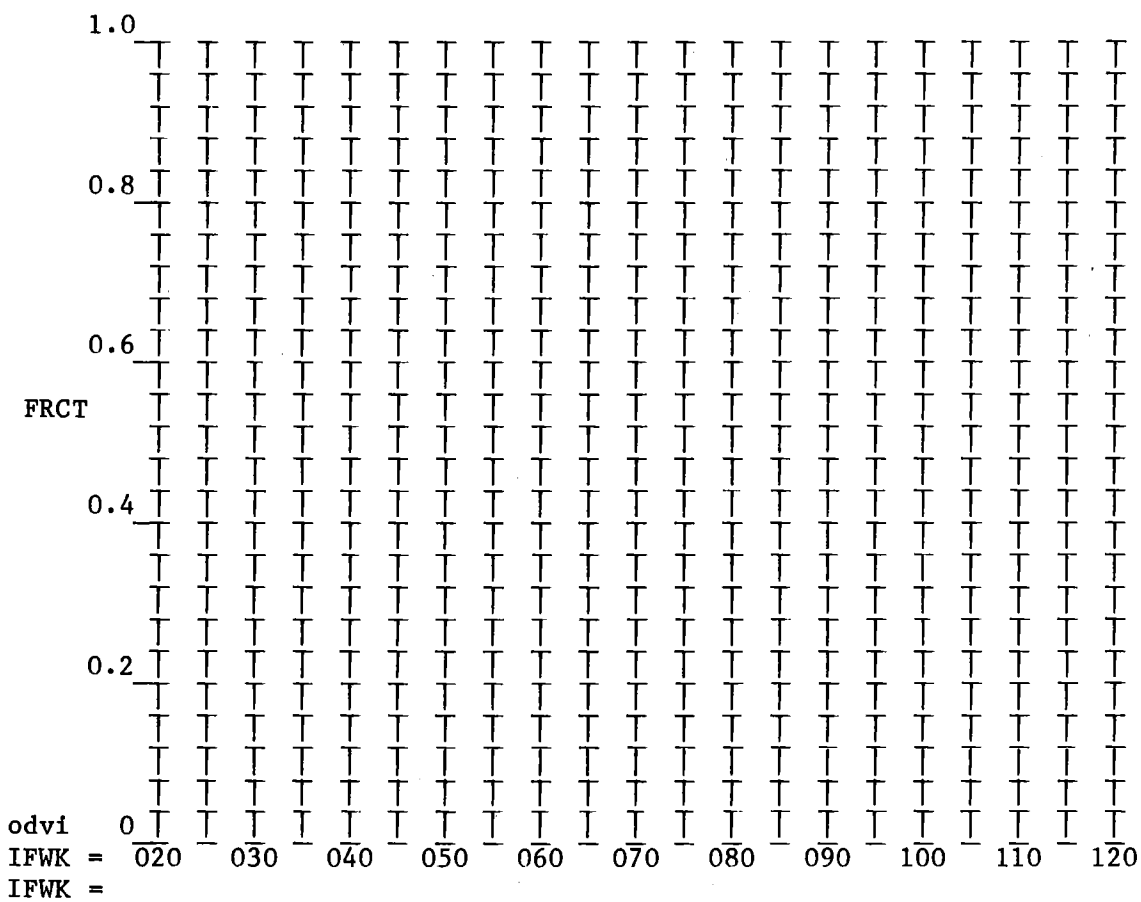
The lack of data on the body compositions of different species of wild ruminants makes it necessary to derive first approximations based on other species. Extrapolation of the equations in WORKSHEET 2.1a to moose (500 kg) does not work. How, then, can the body composition of moose be estimated?

If the assumption that water, fat, protein, and ash fractions of moose and other wild ruminants are propotional to those of white-tailed deer, then the weights of these fractions can be expressed as a fraction of the total and that fraction multiplied by the weight of the new species. Illustrating with the equation for water:

$$WATF = e^{(0.8982 \ln IFWK - 0.0827)}/IFWK$$

where WATF = water fraction. The result is a decimal fraction.

Calculate the fractions for 20, 30, 40 . . . kg for deer for each of the four chemical groups and curve-fit the results. Then, use the resulting equations by making the weights of the new species proportional to the weight of white-tailed deer and complete the first approximations for different species. Relabel the x-axis with IFWK for the species considered.



UNIT 2.2: CHEMICAL COMPOSTION OF MILK

Milk is produced by the epithelial cells lining alveoli of the mammary glands. Production is stimulated primarily by a lactogenic hormone, prolactin, from the anterior pituitary gland (Pantelouris 1967). The sucking stimulus plays a part in the continuation of production; lactation diminishes rapidly if the milk is not removed from the udder.

The chemical composition of milk changes during the lactation period. Few measurements have been made of the composition of milk of any wild ruminant for the entire lactation period, however. The references listed usually contain chemical composition data at one point or for only a small part of the lactation period.

The chemical composition of milk changes during the lactation period. Few measurements have been made of the composition of milk of any wild ruminant for the entire lactation period, however. The references listed usually contain chemical composition data at one point or for only a small part of the lactation period.

Fat and energy. The fat content of milk is the major determinant of the caloric energy in milk. A formula for determining the kcal/kg of milk is in Blaxter (1962:171), with the caloric energy content a direct function of percent fat. The equation given is:

$$\text{Kcal/kg milk} = 304.8 + 114.1(f)$$

where f is the percentage of fat in the milk. The equation was derived from "many thousands" of samples from dairy cows milks varying in composition from 2.8 to 6.2% fat. Calculations of the caloric content of milks from different species of wild ruminants are explained in WORKSHEET 2.2b.

Protein. Milk is relatively high in protein, a biological necessity when it is the main or only source of nutrients for the neonate. Wild ruminant neonates begin grazing a few days after birth and extract proportionately more of their nutrient requirements from plants as their rumens develop. Since their total protein requirement is increasing as they grow rapidly during the suckling period, the contribution of milk proteins is significant. The chemical breakdown of milk protein can be quite extensive and is beyond the intent of this UNIT and available data on wild ruminant milk. Total nitrogen, which may be determined with the Kjeldahl method, is a good indicator of the total protein content of milk as only about 5% of total nitrogen is milk is present as non-protein materials (Lampert 1975:47).

Lactose. Lactose is the main carbohydrate found in milk. Called milk sugar, it is a disaccharide that can be hydrolyzed into two other sugars, glucose and galactose (Lampert 1975:49). The lactose in normal cow's milk ranges from 4.4 to 5.8% (Nicherson 1965:225). A table of composition of milk of 23 mammals in Nicherson lists reindeer as having 2.4% carbohydrate [lactose] which is only 1/2 of the amount in cow's milk. Such single numbers may be misleading because changes in the chemical composition of

milk over the entire lactation period are certain to occur and probably have not been considered since milk collections of free-ranging animals are difficult to make over the entire lactation period.

Minerals. Minerals, collectively referred to as the ash content, make up 1% or less of the total content of milk. The minerals are not abundant, but they are important in neonate nutrition since skeletal growth is rapid early in life. The percents of seven minerals in milk and their percents in the ash of milk are listed by Lampert (1975:51). The seven minerals are potassium, calcium, chlorine, phosphorous, sodium, magnesium, and sulfur. There are also several minerals found in very small, or trace amounts.

Vitamins. Milk contains vitamins A, B, D, and E all necessary for metabolic processes.

Water. Milk is composed of nearly 90% water, which carries the lactose, minerals, salts, and water-soluble vitamins in solution.

LITERATURE CITED

Blaxter, K. L. 1962. The energy metabolism of ruminants. Hutchinson & Co., London. 327 p.

Lampert, L. M. 1975. Modern Dairy Products. Chemical Publishing Co., New York. 437 p.

Nicherson, T. P. 1965. Chapter 6 In Webb B. H. and A. H. Johnson, Editors. Fundamentals of dairy chemistry. The Avi Publishing Company, Inc., Westport, Connecticut. 827 p.

Pantelouris, G. M. 1967. Introduction to animal physiology and physiological genetics. Pergamon Press, Oxford. 497 p.

REFERENCES, UNIT 2.2

CHEMICAL COMPOSITION OF MILK

BOOKS

type	publ	city	page	anim	kewo	auth	year
aubo	isup	amia	291	dome	secretion of milk (4th ed)	espe, w; smith, v	1952
edbo	saco	phpa	584		handbook of biological dat	spector, ws	1956
aubo	isup	amia	291	dome	physiology of lactation	smith,vr	1959
aubo	hutc	loen	307	dome	energy metabol of ruminant	blaxter, kl	1962
aubo	jblc	phpa	273		nutrition, compos of milk	kirchgessner,m; /	1967
aubo	pepr	oxen	497		anim physiol, physiol gene	pantelouris, gm	1967
edbo	acpr	nyny			milk protein; chem, molecu	mckenzie,ha	1970
aubo	whfr	sfca	317	dome	biology of lactation	schmidt,gh	1971
edbo	butt	loen	467	many	lactation	falconer,ir,ed	1971
edbo	acpr	nyny			lactation	larson,bl; smith,	1974

SERIALS

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JRPFA	37--1	67	84	cerv	composi milk, cerv species	arman,p; kay,rnb/	1974

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JWMAA	24--4	439	441	odvi	rearing, breedi fawns, cap	murphy,da	1960
JWMAA	25--1	66	70	odvi	deer milk, substitute milk	silver,h	1961
JWMAA	29--1	79	84	odvi/comp	milk,bld nursng doe,f	youatt,wg; verme/	1965

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	37--2	217	218	odhe	composit, deer milk, calif	hagen,hl	1951
JOMAA	36--3	473	474	odhe	mule deer milk	browman,lg; sears	1955
JOMAA	58--3	420	423	odhe	changes nutri compos, milk	mueller,cc; sadle	1977
JWMAA	20--2	212	214	odhe	postnat grow, comp of milk	kitts,wd; cowan,/	1956
JWMAA	44--2	472	478	odhe	milk yield, black-tailed d	sadleir,rmfs	1980

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
BIJOA	153-3	647	655	ceel	whey proteins, red de milk	mcdougall,ei; ste	1976
JRPFA	37--1	67	84	ceel/comp	yield of milk, red d	arman,p; kay,rnb/	1974
ZTTFA	31--5	227	238	ceel	comp, milk, red deer, pt 1	brueggemann,j; d/	1973

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	48--2	213	215	alal	gros comp milk, fat, minrl	cook,hw; rausch,/	1970
JWIDA	12--2	202	207	alal/milk, hair, element relati		franzmann,aw; fl/	1976

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	45--6	1101	1106	rata	milk, gros comp, fat, prot	hatcher,vb; mcew/	1967
JDSCA	57-11	1325	1333	rata/milk comp chang, grazing r		luick,jr; white,/	1974
ZOBIA	32--6	746	750	rata	alal, electroph, milk prot	shubin,pn; turub/	1971

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	37--2	217	218	anam	odhe, compos milk, compars	hagen,hl	1951

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
JOMAA	36--2	305	308	bibi	the lipids in bison bison	wilbur,cg; gorski	1955

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CAFGA	41--2	131	143	ovca	rearing lambs in captivity	deming,ov	1955
CJZOA	43--5	885	888	ovca	milk, gross comp, fat cons	chen,ech; blood,/	1965

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	48--4	629	633	ovda	*milk, stage lact, composit	cook,hw; perarso/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	34--6	569	571	obmo	gross composition of milk	tener,js	1956
CJZOA	48--6	1345	1347	obmo	gros comp,ftty acid, minrl	baker,be; cook,h/	1970

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CJZOA	47--1	5	8	oram	gross compos, fat acid con	lauer,bh; blood,/	1969
CJZOA	47--2	185	187	oram	miner const, milk, arctic	luer,bh; baker,b	1969

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
CBCPA	42b-2	323	328	many	electrophesis milk casins	lauer,bh; baker,b	1972
CJZOA	49--4	551	554	many	carbohydra content, casein	baker,be; lauer,b	1971
CJZOA	55--1	231	236	many	amin acid comp casein milk	lauer,bh; baker,b	1977

CODEN	vo-nu	bepa	enpa	anim	kewo	auth	year
IZYBA	4----	333	342	many	composit milk wild animals	ben shaul,dm	1962

CHAPTER 2, WORKSHEET 2.2a

Chemical composition of milk

The chemical composition of milk changes as the lactation period progresses. The data on chemical composition should be evaluated in relation to both the days into lactation (DILA) and the fraction of the lactation period (FRLP) that has passed. The format suggested below may be useful for tabulating chemical compositions and evaluating changes through the lactation period.

			CHEMICALS					
spec	DILA	FRLP	FAT-	PRTN	MNRL	WATR	LCTS	reference

spec = species
FAT- = fat
PRTN = protein
MNRL = mineral
WATR = water
LCTS = lactose

CHAPTER 2, WORKSHEET 2.2b

Energy content of milk

The amount of energy in milk depends on the chemical composition of the milk. Milk with a high fraction fat fraction contains more energy than milk with a low fat fraction. The equation given by Blaxter (1962:171) based on research by Overman and Gaines (1933) and Gaines and Overman (1938) for calculating kcal/kg milk as a function of the percentage of fat in the milk. The equation, with letter symbols modified, is:

$$ECPK = 304.8 + 114.1\ FATP$$

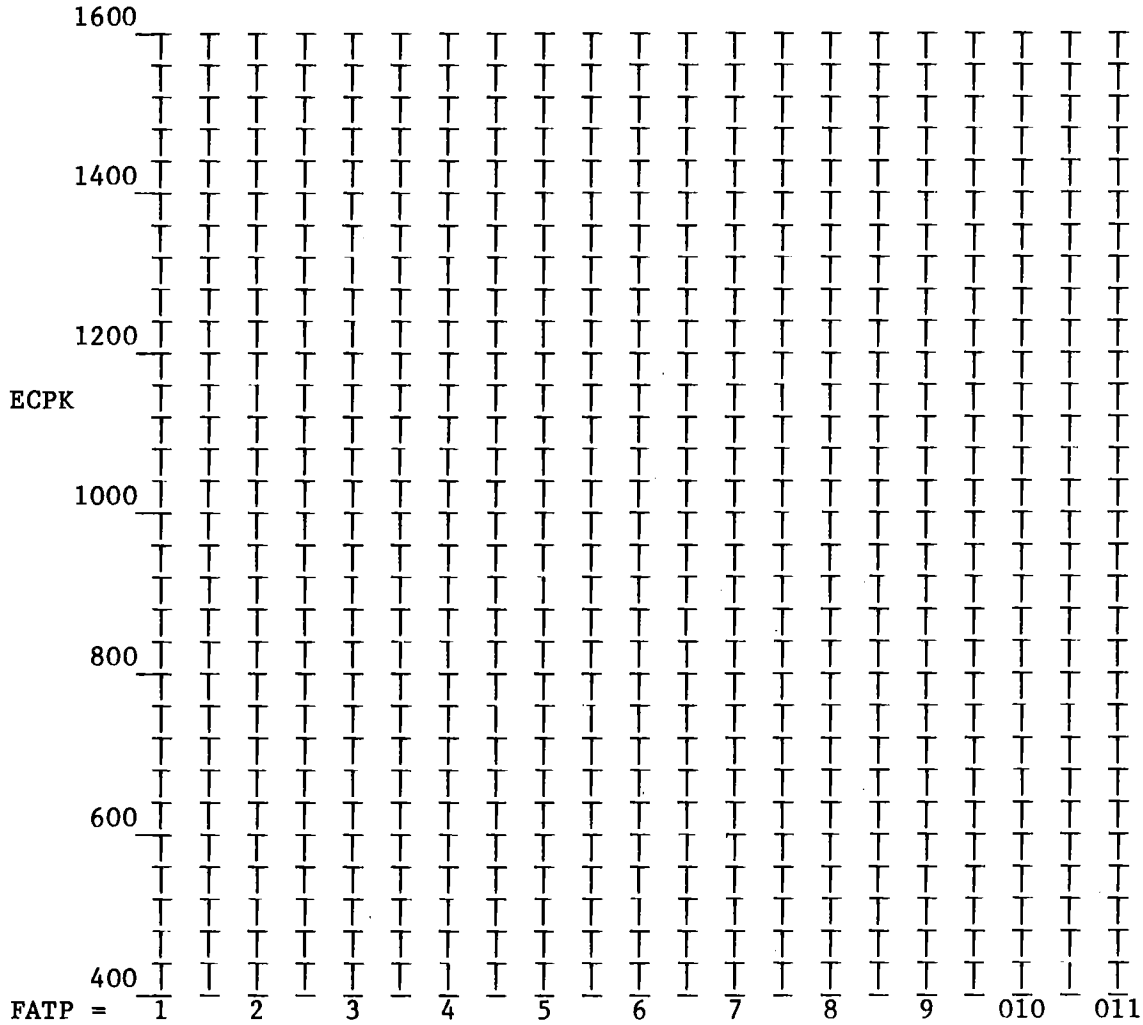
where ECPK = energy content per kg, and
FATP = fat percent.

Note that FATP is percent and not fraction. Milk with FATP = 4.0 has an energy content of 761 kcal/kg.

The equation has been derived from data on dairy cattle with milk varying from 2.8 to 6.2% fat. It should provide reasonable estimates when used for wild ruminants whose milk may contain more than 6.2% fat.

Lactation is a costly process. The use of this equation along with equations in CHAPTER 7 for calculating milk production results in estimates of the energy cost of milk, which is a significant part of the total cost of the ecological metabolism of free-ranging females.

Calculate ECPK and plot the line on the graph on the next page.



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