COMPARATIVE ASSESSMENT OF THE PROXIMATE, MINERAL, VITAMIN COMPOSITIONS AND MINERAL SAFETY INDEX OF SOME SELECTED DOMESTIC ANIMALS' FURS

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ABSTRACT

The proximate, mineral, vitamin composition and mineral safety index in the furs of four domestic animals (goat, sheep, cow and pig) were determined using standard analytical methods. The results showed that the furs of all the animals were characterized by high protein content (90.2 – 91.1 g/100g) with the highest concentration in cow's fur. Among the minerals, potassium was the most concentrated with values (mg/100g) ranging from 337- 347 and a CV % of 1.25; Na (68.2 – 81.2, CV % (8.61)), Ca (33.6 – 41.3, CV % (8.87)), Mg (10.1 – 12.4, CV % (10.4)). The toxic elements (Cd, Pb) were all of very low concentrations among all the samples (0.0006 – 0.0067). The mineral ratios were all within the acceptable range except the miliequivalent ratio ([K/(Ca+Mg)]) (12.8 – 14.7) and Na/Mg (5.68 – 6.72). The mineral safety index of the elements examined showed excess selenium (Se) in goat and cow furs (14.2, -0.24 and 15.3, -1.32 respectively). The only vitamin of significant concentration was vitamin E (1.78 – 2.07 mg/100g, CV %, (6.64)) whereas others were less than 0.00001 mg/100g. The Chi-square test results showed that there were no significant differences among all the parameters determined except in the group of mineral ratios (Ca/Pb, Zn/Cd, Fe/Co and K/Co).

Keywords: Animal furs, proximate, mineral, vitamins composition, mineral safety index

No of Tables: 5 **No of References: 39**

INTRODUCTION

Fur refers to the body hair of non-human mammals also known as the pelage (like the term plumage in birds). It is an outgrowth of protein. The major composition of hair fibre is keratin (they are protein which project from the epidermis, though it grows from hair follicles in the dermis). Robbins (2012) in his report on human hair gave the details about endogenous and exogenous hair lipids and the critical involvement of protein and free lipids in the surface layers of hair including lipid contributions to the protective properties of the cuticle and the iso-electric point. He further explained that depending on moisture content (up to 32 % by weight), human hair consists of approximately 65 to 95 % proteins. Animal coats are not only functionally important butalso fundamental for signalling (i.e. aggression) and a loss of fur could have serious consequences for survival. In humans, the loss of scalp or body hair is non-lifethreatening; neither is it of any significance for survival. It can however, adversely affect an individual's quality of life. The integrity of normal skin and hair function relies largely on an adequate and balanced nutritional intake (Ryder, 1958).Animals' coats are the major chemicalindicator that best reflect the quality of feed, nutrition, climate as well as the environment. According to Ramirez-Perez et al.(2000) reported that factors such as breed, age, sex as well as physiological and health state cause appreciable variation in the chemical composition of wools and coats. It has been reported that certain elements (Ca, Mg, K, Zn, Cu, Co, Se and F) were present in higher concentration while S and Mo were present in lower concentrations in the wool of sheep or goats suffering from fleece-eating (Shima Zheng) (Huang and Chen, 2001). Also in a report by Enneet al.(1989), high concentrations of toxic metals (Cd and Pb; Cu and Zn) were observed in sheep wool from mining regions in Italy. This report was further established by the observations of Kolaczet al. (1999) in which higher concentrations of As, Cd, Ba, Fe, Mn, Pb, Ti and Zn were observed in the case of sheep from areas under the influence of the copper industry in comparison to ecologically clean regions. Patkwoska- Sokolaet al, 2009) reported that hair is considered to be a good bio-indicator of the state of the environment, soil, water and air pollution, even better than blood, urine or animal milk (Farmer and Farmer, 2000; Gabryszuket al., 2010). Varying concentrations of elements and heavy metals have also been reported for sheep wool from three different countries (Polandand Cyprus) (Patkwoska- Sokolaet al., 2003).

Trace elements are crucial for the proper functioning of all living organisms (Jadwiga and Wanda, 2013). Some of them, however, can induce metabolic disorders. Both human and animals derive trace elements from plants, whose mineral composition is also with the natural abundance of elements in soils or with industrial pollution (Maia et al., 2006). Investigations of the elemental composition of human hair for assessment of the level of minerals in a whole organism have been meticulously studied (Deshmukh et al.., 2010; Jadwiga and Wanda, 2013). Jadwiga and Wanda (2013) reported that the determinations of mineral content of farm animal's hair and fur could be helpful in assessing the nutritional status versus the requirements for certain substances or to determine their toxicity. They further reported that hair may also serve as a reliable source of data which facilitates monitoring of the body's mineral status owing to a relatively long deposition of bio-elements as well as its stability in comparison to blood (Jadwiga and Wanda, 2013). A positive relationship has been observed between the levels of minerals in milk and hair of cows kept on conventional and organic farms with the system production (Gabryszuket al., 2010). Jadwiga and Wanda (2013) while investigating the influence of horse breed and housing system on the level of selected elements in horses' hair observed that the content of minerals in the hair of domestic animals may vary depending on the breed and dietary factors.

Hair and fur are used to control the abuse of animals for therapeutic purposes as well as the application of steroids (Gratecós-Cubrasiet al., 2006). Providing that concentrations of certain elements and nutrients in the fur of these animals may be taken as an indication of the need for their supplementation, the impact of such factors as breed, sex, hair colour, exposure to pollution and nutrition cannot be neglected (Maia *et al.*, 2006). Very little information is available to elucidate the effects of these factors on the furs of some of our domestic animals in the Southwestern part of Nigeria (goat, sheep, cow and pig). The objective of the research is to investigate the proximate, minerals and vitamin composition and mineral safety index on the fur of selected domestic animals (goat, sheep, cow and pig) with a view to establishing the compositional variations and/or similarities based on the analyses of four domestic animals' furs on the analytical results as already stated.

MATERIALS AND METHODS

Animals

The research included ten animals from each type (cow (*Bos primigenius*), sheep (*Ovisaries*), goats (*Capraaegagrushircus*) and pig (*Susscrofa*)), selected from the various slaughtering houses within Ado – Ekiti metropolis. The animals were within the ages ranging from 3 to 4 years. They had unlimited access to grass or pasture and additionally received food remains from residential areas. They were usually kept in a free range system all year round and were of good health.

The furs designated for analysis were collected from all the selected animals in the month of January. Fur samples of 50 g each were obtained from the nape area nearest to the skin and packed into clean plastic bottles. The individual animal furs were properly grounded into fine powder and kept in air-tight plastic bottles prior to analysis.

Proximate analysis

Moisture, total ash, fibre and ether extract of the samples were determined by the methods of the AOAC (2005). Nitrogen was determined by the micro-Kjeldahl method and the crude protein content was calculated as N (per gram) x 6.25 (Pearson, 1976). Carbohydrate was determined by differences. All the proximate results were reported in g/100 g dry weight. The energy values were obtained for carbohydrates (x 17 kJ per gram), crude protein (x 17 kJ per gram) and crude fat (x 37 kJ per gram) for each of the samples. Determinations were in duplicate. Representative aliquots of 2 – 4g were taken for analysis.

Mineral analysis

Minerals were analyzed using the solutions obtained after dry ashing the samples at 550 °C and dissolving it in 10 % HCl (25 ml) and 5 % lanthanum chloride (2 ml), boiling, filtering and making up to standard volume with deionized water. Phosphorus was determined colorimetrically using a Spectronic 20 (Gallenkamp, London, UK) instrument, with KH_2PO_4 as a standard. All other elements (Ca, Mg, Zn, Fe, Mn, Cu, Pb, Cd and Co) were determined by atomic absorption spectrophotometry, Model 403 (Perkin-Elmer, Norwalk, Connecticut, USA). Na and K were determined by flame photometry, Model 405 (Corning, Halstead Essex, UK) using NaCl and KCl to prepare standards.All determinations were made in duplicate. All chemicals used were of analytical grade, and were obtained from British Drug House (BDH, London, UK).

The detection limits for the metals in aqueous solution had been determined just before the mineral analyses using the methods of Varian Techtron, giving the following values in µg/ml: Fe (0.01), Cu (0.002), Na (0.002), K(0.005), Ca(0.04), Mg(0.002), Zn (0.005), Mn (0.01) and Cr (0.02) (Varian Techtron, 1975; Varian Australia, 1997). The optimal analytical range was 0.1 to 0.5 absorbance units with coefficients of variation from 0.9-2.2 %.

Statistical analyses and other calculations

The results were analyzed statistically, the mean, standard deviation and coefficients of variation per cent (CV %) were calculated (Steel and Torrie, 1960). The percentage contribution to energy due to protein (PEP), due to total fat (PEF) and due to carbohydrate (PEC) as PEP %, PEF % and PEC % respectively were calculated. The percentage utilizable energy due to (60 %) protein (UEDP %) was also calculated. Ca/P, Na/K, Ca/Mg, Na/Mg, Zn/Cu, Fe/Cu, Ca/Pb, Fe/Pb, Zn/Cd, Fe/Co, K/Co and the milliequivalent ratio of [K/(Ca +Mg)]; the mineral safety index (MSI) of Na, Mg, P, Ca, Fe, Se, Cu and Zn were also calculated (Hathcock, 1985). To calculate MSI, we have:

$$\text{MSI} = \frac{\text{MSI (standard) x Dataor Research Results}}{\text{RAI (standard)}}$$

RAI is recommended adult intake; CV in the Table will represent calculated value (CV) of calculated MSI from research results.The differences between the standard MSI and the MSI of the samples were also calculated.

The Chi-square analysis (χ^2) was carried out and the level of significance was determined at a critical level of p = 0.05.

RESULTS AND DISCUSSION

Table 1 shows the results of proximate composition, energy and percentage energy contributions from protein, fat and carbohydrate. In all the four fur samples, levels of crude fibre and ash were generally low (0.600 – 0.009 g/100g). The values were comparably lower than those reported for eight organs of guinea fowl (0.13 – 4.06 g/100g) (Adeyeye and Adesina, 2014) and cattle hides subjected to various processing methods (1.17 – 1.67) (Akweteyet al., 2013). The fat contents in the fur samples ranged from 3.15 to 3.60 g/100g with a CV % value of 6.58. These values were fairly comparable to the reports of Akweteyet al. (2013) for fats in cattle hide under various processing methods (4.00 – 4.67 g/100g). The protein contents in the fur samples ranged from90.2 to 91.1 g/100g and a CV % of 0.450 showing that the values were very closely varied. These values fell within the range reported for human hair (65 to 95 % proteins) depending on its moisture content (Robbins, 2012) and comparably higher than those reported for variety organs of guinea fowl (17.7 – 81.5 g/100g) (Adeyeye and Adesina, 2014).

Energy (kJ/100g) in the fur samples ranged from 1698 and 1709 with a coefficient of variation percent of 0.338, showing that the values were closely varied. The values were much better than those reported for the muscle and skin of turkey-hen (Adeyeye and Ayejuyo, 2007). The various energy contribution percent had PEP % (percentage energy contribution due to protein) as the highest value in all the four samples and among all the other contribution percentages; 89.7 to 90.6 %. This shows that the greater part of the fur samples have protein concentrations in terms of energy that would be contributed if they are to serve as protein-energy producers in animal feeds. The percentage energy contribution due to fat (PEF %) and percentage energy contribution due to carbohydrates (PEC %) values were generally low (7.00 – 8.00 and 1.59 – 1.79 respectively).

The utilizable energy due to protein (UEDP %) for the samples (assuming 60 % utilization) ranged from 54.2 to 54.7 with a CV % value of 0.467. The values observed were comparably much higher than the recommended safe level of 8 % (Adeyeye and Ayejuyo, 2007) in man, however, on the other hand the values were much higher than those reported for the variety organs of guinea fowl (Adeyeye and Adesina, 2014), body parts of male and female West African fresh water crab (*Sudananautes africanus africanus*) (Adeyeye et al., 2010).

Table 2 shows the mineral compositions of the fur samples from the selected domestic animals. These minerals comprises of macro elements and heavy metals. As a main macro element, calcium (Ca) content ranged from 33.6 to 41.3 mg/100g and a CV % value of 8.87. The highest level of Ca was found in the goat fur while the lowest one in the pig fur. Some authors (Krosnicka- Bombala, 1996; Patkwoska-

Sokolaet al., 2009) have reported the range of basic macro element (Ca) in sheep wool from 646 to 1721 mg/kg (64.6 – 172.1 mg/100g) and a low level of Ca was observed by Aydin (2008) in wool from male lambs collected in Turkey. Phosphorus (P) concentration ranged from 5.96 to 8.05 mg/100g with a CV % value of 14.0. The highest value was recorded in pig fur while the lowest value was in sheep fur. Huang and Chen (2001) have reported a higher range of phosphorus in sheep wool (16.3 – 30.0 mg/100g). Patkwoska-Sokolaet al.(2009) have also reported phosphorus contents in sheep wools from Poland, Greece and Syria to range from 14.8 to 28.4 mg/100g. This literature values were comparably higher than the observed levels in the present report. The difference in the levels as reported above could be due to the deference in environmental and nutrition status. The magnesium contents in the fur samples were generally low (10.1 – 12.4 mg/100g and a CV % value of 10.4). Equal amounts of Mg were observed both in pig and goat furs (12.4 mg/100g), this value invariably was the highest in the range. Some authors (Krośnicka- Bombala, 1996; Patkwoska-Sokolaet al., 2009; Gabryszuket al., 2000; 2010) have reported a wide range of Mg concentration in sheep hair (12.08 - 59.08, 4.78 – 26.34, 4.78 - 59.0 mg/100g) respectively. The sodium (Na) content in the fur samples were in the range of 68.2 to 82.1 mg/100g with a CV % value of 8.61. The fairly high levels of Na observed in the samples could be due to the usual supplementation given to these animals as part of their ration or their biochemical requirements or both. In all the fur samples and among all the analyzed minerals, potassium (K) had the highest concentration with the values ranged from 337 to 347 mg/100g. Lower concentrations of K have earlier been reported by Patkwoska-Sokolaet al.. (2009) for sheep wool from Poland, Greece and Syria (643 – 755 mg/kg) (or 64.3 – 75.5 mg/100g).

In the group of trace elements, we have Co, Cu, Fe, Mn, Zn and Se in the fur samples. Trace elements are crucial for the proper functioning of all living organisms. Some of them (especially toxic metals), however, can induce metabolic disorders. Both humans and animals derive trace elements from plants whose mineral composition is associated with the natural abundance of elements in the soils or with industrial pollution. The growing public awareness on the hazards of environmental contamination compels the monitoring of elements and other toxic substances in air, soil, food and living organisms (Jadwiga and Wanda, 2013). Cobalt (Co) content ranged from 0.0009 to 0.0014 mg/100g with the highest in goat fur and the lowest in pig fur. Kolaczet al., (1999) reported Co ranged from 0.0186 to 0.1873 mg/kg in sheep wool, depending on the degree of environmental pollution or the country of origin for healthy sheep and goat wool from China: low content of Co were reported (Huang and Chen, 2001) whereas a male lamb in Turkey were reported to contain 0.59 to 1.36 mg/kg Co (Aydin, 2008). In general, low levels of Fe, Cu, Mn and Se were observed in all the samples of fur analyzed. Sztych and Soroczyńska (1994); Kolacz et al., (1999) and Ramirez-Perez et al.(2000) have also reported low concentration of these elements in the wools and hair of animals such as sheep, goat and lambs. According to Scott (1991), a normal Zn content in sheep wool ranges from 3.5 – 19.5 mg/100g, depending mainly on its supply in animal diet and the physiological state of sheep (Patkowska- Sokolaet al., 2009). Other authors have proved significant differences in this element content between the Rambowllet and Suffolk ewe's wool (Ramirez-Perez et al., 2000). The levels of Zn (0.241 – 0.365 mg/100) in the present samples of animal fur were much lower than the literature values (7.36 – 8.88 mg/100g) (Patkowska-Sokolaet al., 2009). The level of selenium in the present report ranged from 0.066 to 0.077 mg/100g and a CV % of 7.10. Interest in selenium increased due to the discovery of a selenium compound called "factor3". This compound was found to protect animals from fatty infiltration and necrosis of the liver. This also led to the speculation that some type of relationship existed between selenium and vitamin E. Research has shown that selenium deficiency produced recognizable abnormalities in lab animals. They found that selenium supplementation reversed a condition called white muscle disease that occurred in sheep and cattle raised on selenium deficient soils. This led to the suspicion that selenium may be involved as a cofactor in enzyme systems related to cellular oxidation, and that selenium may therefore, play a role in human nutrition as well (David, 1994).

In the group of other heavy metals, we have Pb, Cd and Ni analyzed in the samples. The observed lead (Pb) content was within the range of 0.0055 to 0.0067 mg/100g. The highest value was observed in cow fur and lowest in sheep fur. The high relative value in cow fur might be due to an expanded range of grazing usually explored by cattle rearers. Numerous authors (Enneet al., 1989; Kolaczet al., 1999; Patkowska-Sokolaet al., 2009) have reported a wide range of Pb concentration in animal furs (0.0015 – 0.694 mg/100g). Cadmium (Cd) content observed in the samples was within the range of 0.006 to 0.0040 mg/100g with a CV% value of 71.6. These values varied significantly among the samples. These values were generally low and as a matter of fact very much lower than the values reported by Patkowska-Sokolaet al. (2009) in sheep wool from Greece, Poland and Syria (0.34 to 0.342 mg/kg). On the other hand, the present values of Cd fell within the range reported by Enneet al. (1989);Kolaczet al., 1999 and Aydin, 2008 for some animal wools and hairs (0.0186 to 1.8 mg/kg). Small differences were observed in concentrations of heavy metals in hair and hoof horns of the Polish Konik depending on the housing system. The author also revealed that increased levels of minerals in hair, especially cadmium and lead, occurred during the winter feeding periods (Stachurskaet al., 2011). On the other hand, Kaproñet al.. (2010) obtained lead concentrations at the level of 0.22 mg/kgd.m. for Polish Konik horses kept in the wild during summer. Farmer and Farmer (2000) analyzed the content of some elements in tissues of animals held in regions exposed to industrial pollution and reported that the level of lead depended on its concentration in plants. In addition, the concentration of lead in hair was markedly higher than in soft tissues. However, no such dependency was observed for cadmium, which may suggest that its accumulation in the body depended on other factors as well.

Table 3 contains the various computed mineral ratios (Ca/P, Na/K, Ca/Mg, Ca/K, Na/Mg, Zn/Cu, Fe/Cu, Ca/Pb, Zn/Cd, Fe/Pb, Fe/Co and K/Co), these mineral ratios revealed not only the important balance between these elements, but they also provide information regarding the many factors that may be represented by a disruption of their relationships, such as disease states, physiological and developmental factors, the effects of diet and drugs (Watts, 2010).

Table 1: Proximate composition (g/100g), gross energy (kJ/100g) and energy contributions (%) from the protein, fat and carbohydrate content of selected domestic animals' furs

Parameter	Goat fur	Pig fur	Cow fur	Sheep fur	Mean	SD	CV%	χ^2	Remark
crude fat	3.50	3.60	3.15	3.20	3.36	0.221	6.58	0.044	NS
Crude protein	91.0	90.2	91.1	90.9	90.8	0.408	0.450	0.006	NS
CHO	1.70	1.60	1.70	1.80	1.700	0.082	4.80	0.012	NS
Ash	0.600	0.700	0.750	0.650	0.675	0.065	9.56	0.019	NS
Crude fibre	0.800	0.900	0.800	0.700	0.800	0.082	10.2	0.025	NS
Moisture	2.40	3.00	2.50	2.75	2.66	0.269	10.1	0.081	NS
PEF %	7.78	8.00	7.00	7.12	7.48	0.49	6.59	1.66	NS
PEC %	1.69	1.59	1.69	1.79	1.69	0.08	4.83	0.200	NS
PEP %	90.5	89.7	90.6	90.4	90.3	0.41	0.45	0.094	NS
UEDP %	54.3	54.2	54.7	54.6	54.5	0.255	0.467	0.004	NS
Gross Energy (kJ/100g)	1709	1697	1697	1698	1700	5.75	0.338	0.058	NS

PEP =proportion of energy due to protein, PEF= proportion of energy due to fat, PEC= proportion of energy due to carbohydrate, UEDP=utilizable energy due to protain, SD= standard deviation, CV= coefficient of variation, χ^2 = Chi-square, S=significant, NS= not significant, critical value of χ^2 = 7.815 at P=0.05,

Table 2: Mineral composition (mg/100g) of the selected domestic animals' furs

Minerals	Goat Fur	Pig fur	Cow fur	Sheep fur	Mean	SD	CV%	χ^2	Remark
Fe	0.382	0.391	0.396	0.365	0.383	0.014	3.63	0.0015	NS
Cu	0.289	0.315	0.280	0.275	0.290	0.018	6.09	0.0032	NS
Co	0.0014	0.0009	0.0013	0.0012	0.001	0.0002	18.0	0.0001	NS
Mn	0.364	0.352	0.370	0.343	0.357	0.012	3.34	0.0012	NS
Zn	0.242	0.365	0.242	0.241	0.272	0.062	22.6	0.0417	NS
Pb	0.0062	0.0061	0.0067	0.0055	0.006	0.0005	8.04	0.0001	NS
Ca	41.3	33.6	39.9	37.3	38.0	3.37	8.87	0.898	NS
Mg	12.4	12.4	10.6	10.1	11.4	1.19	10.4	0.372	NS
K	343	339	347	337	342	4.28	1.25	0.161	NS
Na	70.2	82.1	71.0	68.2	72.9	6.28	8.61	1.621	NS
P	6.32	8.05	6.37	5.96	6.67	0.932	14.0	0.391	NS
Se	0.071	0.066	0.077	0.066	0.070	0.005	7.10	0.0011	NS
Cd	0.0006	0.0012	0.0040	0.0030	0.002	0.002	71.6	0.0034	NS
Ni	0.0058	0.0173	0.0058	0.0060	0.009	0.006	65.5	0.0112	NSNS

SD= standard deviation, CV= coefficient of variation, χ^2 = Chi-square, S=significant, NS= not significant, critical value of χ^2 = 7.815 at P=0.05

Table 3: Computed selected mineral ratios of the domestic animals' furs

Ratios	Ref. balance (Ideal)	Acceptable Ideal range	Goat fur	Pig fur	Cow fur	Sheep fur	Mean	SD	CV %	χ^2	Remark
Ca/P	2.60	1.5 to 3.60	6.54	4.18	6.26	6.2509	5.81	1.09	18.8	0.618	NS
Na/K	2.40	1.4 to 3.40	0.205	0.242	0.205	0.202	0.213	0.019	8.95	0.0051	NS
[K/(Ca+Mg)]*	2.20	-	12.8	14.7	13.8	14.2	13.9	0.844	6.08	0.154	NS
Ca/Mg	7.00	3.0 to 11.0	3.34	2.71	3.77	3.68	3.37	0.48	14.2	0.205	NS
Ca/K	4.20	2.2 to 6.20	0.121	0.099	0.115	0.111	0.111	0.009	8.2	0.0022	NS
Na/Mg	4.00	2.0 to 6.0	5.68	6.62	6.72	6.73	6.43	0.509	7.9	0.121	NS
Zn/Cu	8.00	4.0 to 12.0	0.839	1.16	0.862	0.878	0.935	0.151	16.1	0.073	NS
Fe/Cu	0.90	0.2 to 1.60	1.32	1.24	1.41	1.33	1.33	0.07	5.25	0.011	NS
Ca/Pb	84.0	126 to 168	6664	5512	5950	6778	6226	601	9.65	174	S
Zn/Cd	500	750 to 1000	404	304	60.4	80.4	212	169	79.6	403	S
Fe/Pb	4.40	6.60 to 8.80	61.6	64.1	59.1	66.3	62.8	3.09	4.93	0.457	NS
Fe/Co	440	-	273	435	305	304	329	71.9	21.9	47.2	S
K/Co	2000	-	244654	377121	267068	281114	292489	58385	20	34963	S

*milliequivalent ratio, SD= standard deviation, CV= coefficient of variation, χ^2 = Chi-square, S=significant, NS= not significant, critical value of χ^2 = 7.815 at P=0.05

Table 4: Mineral safety index of minerals of some domestic animals' furs

Minerals	TV	Goat Fur		Pig fur		Cow fur		Sheep fur	
		CV	D (% diff)	CV	D(%diff)	CV	D(% diff)	CV	D(% diff)
Ca	10	0.34	9.66(96.6)	0.28	9.72(97.2)	0.33	9.67(96.7)	0.31	9.69(96.9)
P	10	0.05	9.95(95.5)	0.07	9.93(99.3)	0.05	9.95(99.5)	0.05	9.95(99.5)
Mg	15	0.46	14.54(96.9)	0.47	14.53(96.8)	0.40	14.60(97.3)	0.38	14.62(97.5)
Fe	6.7	0.17	6.53(97.5)	0.17	6.53(97.5)	0.18	6.52(97.3)	0.16	6.54(97.6)
Zn	33	0.53	32.47(98.4)	0.80	32.20(97.6)	0.53	32.47(98.4)	0.53	32.47(98.4)
Cu	33	0.43	32.57(98.7)	0.47	32.53(98.6)	0.42	32.58(98.7)	0.41	32.59(98.8)
Se	14	14.2	-0.24(-1.7)	13.2	0.80(5.71)	15.3	-1.32(-9.4)	13.3	0.72(5.14)
Na	4.80	0.67	4.13(86.0)	0.79	4.01(83.5)	0.68	4.12(85.8)	0.65	4.15(86.5)

TV= Table value (standard), CV= calculated value, D= difference (TV-CV), %diff= percentage difference

Table 5: Levels of vitamins in some domestic animal furs

Vitamins	Goat Fur	Pig fur	Cow fur	Sheep fur	Mean	SD	CV%	χ^2	Remark
B1	4.75e-6	5.59 e-6	4.75 e-6	4.63 e-6	4.93 e-6	4.44 e-7	9.00	1.2 e-7	NS
B2	2.18 e-6	2.35 e-6	2.19 e-6	2.14 e-6	2.22 e-6	9.26 e-8	4.18	1.16 e-8	NS
B3	1.39 e-5	5.37 e-5	7.73 e-6	1.87 e-5	2.35 e-5	2.06 e-5	87.7	5.43 e-5	NS
B4	7.78 e-8	1.20 e-7	2.41 e-8	7.07 e-8	7.32 e-8	3.93 e-8	53.7	6.33 e-8	NS
B5	1.24 e-5	3.63 e-5	6.24 e-5	8.57 e-5	4.92 e-5	3.18 e-5	64.6	6.15 e-5	NS
B6	4.41 e-6	1.04 e-5	1.44 e-6	4.04 e-6	5.07 e-6	3.79 e-6	74.7	8.49 e-6	NS
B9	1.14 e-8	5.98 e-9	8.48 e-9	1.27 e-8	9.64 e-9	3.01 e-9	31.2	2.82 e-9	NS
C	2.27 e-5	1.63 e-5	9.76 e-6	2.18 e-5	1.76 e-5	5.97 e-6	33.8	6.05 e-6	NS
Total WS	6.04 e-5	1.25 e-4	8.83 e-5	1.37 e-4	1.03 e-4	3.49 e-5	34.1	3.57 e-5	NS
A	2.59 e-3	1.59 e-3	2.21 e-3	2.46 e-3	2.21 e-3	4.44 e-4	20.1	0.000267	NS
E	1.78	2.07	1.85	1.96	1.92	0.127	6.64	0.0253	NS
K	9.43 e-6	5.64 e-6	6.76 e-6	9.92 e-6	7.94 e-6	2.07 e-6	26.1	1.62 e-6	NS
Total FS	1.78	2.07	1.85	1.96	1.92	0.127	6.61	0.0252	NS
Total (WS+FS)	1.78	2.07	1.85	1.96	1.92	0.127	6.61	0.0252	NS

WS= water soluble, FS= fat soluble, SD= standard deviation, CV= coefficient of variation, χ^2 = Chi-square, S=significant, NS= not significant, critical value of χ^2 = 7.815 at P=0.05

Sodium and potassium reflect expression of the adrenal cortical hormones as well as renal control. Increased production of the adrenal cortical hormone aldosterone increased in the presence of inflammation, or may initiate inflammation. Aldosterone also greatly impacts sodium retention within the body and the hair via increased retention and conservation by the kidney (Watts, 2010). Ideal ratio of Na/K should be 2.4:1. The present report showed that Na/K ratios in the animals' furs were in the range of 0.202:1 to 0.242:1, values considered to be apparently low compared to the acceptable limit. When the ratio of Na/K is found low in the hair/fur it can represent a number of factors such as an anti-inflammatory reaction, a disturbance in neurological and / or renal function and protein catabolism.

Calcium is affected by several hormones and is considered to be under parasympathetic control. Ca/K has an ideal ratio of 4.2:1 and an acceptable range of 2.2 – 6.2:1. The values observed in the furs analyzed were comparably lower than the ideal value. A low Ca/K ratio would indicate an elevation of thyroid expression (Watts, 2010).

Magnesium deficiency is known to increase the stress response so the lower the magnesium level found in the hair, the greater the stress response. Also sodium is regulated by the adrenal hormone and an elevated ratio indicates increased adrenal cortical activity. The Na/Mg ratios in the samples ranged from 5.68:1 to 6.73:1, values considered to be slightly higher than the acceptance range of 2:1 to 6:1 with an ideal level of 4:1. A low value is also linked to a reduced adrenal expression. For Ca/Mg ratio, the ideal should be 7:1, although a range of 3:1 to 11:1 is still acceptable (Watts, 2010), the values of ratios observed in the present report (2.71:1 – 3.77:1) were comparably lower showing the potential of parathyroid non-dominance as well as a reduced insulin level.

Values obtained for Zn/Cu ratio in the samples (0.839:1 – 1.16:1) were generally lower than the ideal range of 8:1. The low values recorded for these two elements might be dueto several physiological and hormonal factors such as estrogen, progesterone and testosterone (Watts, 2010). Cellular respiration and electron transport involve iron and copper, therefore, a distruption in their balance can lead to serious consequences in normal cellular activity. A low or high ratio of Fe/Cu can effect neurological dysfunction affecting neurotransmitter and causing lipid peroxide damage within neurological tissues. The ratios (Fe/Cu) in the present report (1.24:1 – 1.41:1) were slightly higher than the acceptable limit of 0.9:1. An elevated Fe/Cu in the hair may indicate a potential for chronic bacterial infection whereas a lower value is associated with iron deficiency as well as thyroid disturbance (Watts, 2010).

The toxic and other metal metal ratios considered were Ca/Pb, Zn/Cd, Fe/Pb (toxic ratios), Fe/Co and K/Co (other ratios) in the samples. Ca/Pbratios obtained in the present report (5512:1 – 6778:1) were comparably higher than the acceptable limit of 84:1 (Watts, 2010). This shows that there is no indication of potential interference of lead with metabolic process. The high ratios recorded for Zn/Cd (60.4:1 – 404:1), Fe/Pb (59.1:1 – 66.3:1), Fe/Co (273:1 – 435:1), and K/Co (267068:1 – 377121:1) indicate that these toxic metals and the others would not interfere with the metabolic processes in the organisms.

The Ca/P was generally greater than 0.5 which is the minimum ratio required for favourable Ca absorption in the intestine for bone formation in animal nutrition (Nieman et al., 1992). However Ca/P values in goat fur (6.54:1), pig fur (4.18:1), cow fur (6.26:1) and sheep fur 6.25 (6.25:1) were higher than 0.5. The high Ca/P values would enhance strong bone development since absorption under this condition would be high. The Ca/P ratio is reported to have some effect on Ca absorption in the blood of many animals (Adeyeye et al., 2012). The milliequivalent ratios of [K/(Ca+Mg)] (12.8:1 – 14.7:1) were all greater than 2.2. This meant carcass from our samples might promote hypomagnesaemia in man (NRC, 1989).

The mineral safety index values are depicted in Table 4. The standard minerals safely index (MSI) for the minerals are Na (4.8), Mg (15), P (10), Ca (10), Fe (6.7), Zn (33), Cu (33), Se (14). For Ca, P, Zn, Cu, Fe, and Na, all MSI values were low except for Se. Mineral safety index (MSI) were not calculated for K, Mn, Co, Pb, Ni and Cd because no MSI standards were available for them. Na, Ca, Mg, Cu, Zn and P results were all within the standard MSI whereas some values of calculated MSI in Se were greater than their corresponding standard MSI. For Se, this greater MSI was observed in goat fur (14.24 or -0.24) and cow fur (15.3 or -1.32). For Na, Ca, Mg, Cu, Zn and P all the calculated MSI were lower than standard MSI and hence within the USRDA (Hathcock, 1985). The implication of the above is that abnormally high levels of Se present in goat and cow fur samples could lead to the overloading of the body of the consumer that consume the carcass of goat and cow these two animals.

Vitamin E is a term used to refer to eight molecules, which are divided into two categories: tocopherols and tocotrienols. Each category is further divided up into alpha (α), beta (β), gamma (γ), and delta (δ) vitamers. The vitamer α-tocopherol is considered to be the 'main' vitamer, but the gammas (γ-tocopherol and γ-tocotrienol) are also popular research topics, due to their presence in the diet. Collectively, these compounds are called vitamin E. Vitamin E supplements almost always contain α-tocopherol. Vitamin E was one of the first two antioxidant compounds to be sold as dietary supplements, the second being vitamin C. It is sometimes used as the 'reference' antioxidant compound when fat soluble compounds are being researched. Vitamin E may function as a signaling molecule within cells and for phosphate groups. As shown in Table 5, the only vitamin of significant concentration was vitamin E (1.78 – 2.07 mg/100g, CV %, (6.64)) all other vitamins were of very low insignificant concentrations.Vitamin E is a powerful antioxidant that prevents the formation of lipid hydroperoxides from unsaturated phospholipids present in sub-cellular membranes (McDowell, 1989). Vitamin E and selenium are antioxidants that are related to immune function in domestic animals (Finch and Turner, 1996). Milad et al.(2001) reported that they also protect leukocytes and macrophages during phagocytosis, a mechanism whereby mammals immunologically kill invading bacteria.

Statistical Analysis

The report of statistical analysis (Chi-square test at p =0.05) showed that there are no significant differences between all the parameters from proximate, vitamin and mineral composition except in the following ratios: Ca/Pb, Zn/Cd, Fe/Co and K/Co.

Conclusion

Thisstudy indicates that the proximate, mineral and vitamin profiles of the selected four domestic animals' furs have closely varied compositions. In the results, protein contents were very high and could be used in supplementing fish feed, although the digestibility needs to be carried out. UEDP % levels were also very good to support utilization. The samples were high in the following minerals: K, Ca, Na whereas for the toxic metals, the values were generally very low, an indication that these animals were not exposed to them although their presence could be a signal on the onset of pollution of these metals either from the feed stuffs, water air, etc.Vitamin E was the only vitamin with significant concentration among the entire vitamins in all the samples. Because of the low concentrations of some of the parameters investigated, the feeds of the animals should be supplemented with minerals and vitamins for optimal nutritional performance as well as being properly prepared for human consumption in their later carcass.

REFERENCES

Adeyeye, E.I and Ayejuyo, O.O.; Proximate, amino acid and mineral composition of Turkey- hen muscle and skin. Orient. J. Chem., 23(3), 879-886, 2007

Adeyeye, E.I. and Adesina, A.J.; Proximate, mineral compositions and mineral safety index of eight organs of guinea-fowl (*Numidameleagris*). Frontiers in Food Science and Technology, 1(1):7-13, 2014

Adeyeye, E.I., Olanlokun, J and Falodun, T.O.; Proximate and mineral composition of whole body, flesh and exoskeleton of male and female common West African fresh water crab *Sudananautes africanus africanus. Pol. J. Food Nutr. Sci*., 60(3), 213-216, 2010

Adeyeye, E.I., Orisakeye, O.T and Oyarekua, M.A.; Composition, mineral safety index, calcium, zinc and phytate interrelationships in four fast-foods consumed in Nigeria. Bulletin of Chemical Society of Ethiopia, 26(1): 43-54, 2012

Akwetey W. Y., Eremong D. C. and Donkoh A.; Chemical and nutrient composition of cattle hide ("Welle") using different processing methods. J Anim Sci Adv., 3(4): 176-180, 2013

AOAC. *International Official Methods of Analysis*. Association of Analytical Chemists, 18th Edn. Maryland, USA, 2005

Aydin, I.; Comparison of dry, wet and microwave digestion procedures for the determination of chemical elements in wool samples in Turkey using ICP-OES technique. Microchemical J. 90, 82-7, 2008

David L. W.; The nutritional relationships of selenium. Journal of Orthomolecular Medicine, 9(2): 110-117, 1994

Deshmukh, N., Hussain, I., Barker, J., Petroczi, A and Naughton, D.P.; Analysis of anabolic steroids in human hair using LC-MS/MS. *Steroids*, 75(10): 710-714, 2010

Enne, G., Leita, L., Giardini, I and Sequi, P.; Relationship between the level of environmental contamination with heavy metals and their accumulation in sheep tissues. Medycyna Wet. 9-10, 565-8, 1989

Farmer, A.A and Farmer, A.M.; Concentrations of cadmium, lead and zinc in livestock feed and organs around a metal production centre in eastern Kazakhstan. Sci. Total Environ, 257: 53-60, 2000

Finch, J.M and Turner, R.J.; Effects of selenium and vitamin E on immune response of domestic animals. Res. Vet Sci., 60: 97 – 109, 1996

Gabryszuk, M., Klewiec, J., Czauderna, R., Baranowski, A and Kowalczyk, J.: The content of mineral compounds in sheep wool depending on the breed and physiological state. RoczNauk Zoot Suppl. 5, 147-51, 2000 [in Polish]

Gabryszuk, M., S£oniewski, K., Metera, E and Sakowski, T.; Content of mineral elements in milk and hair of cows from organic farms. *J. Elementol*., 15(2): 259-267, 2010

Gratacós-Cubarsi, M., Castellari, M., Valero, A and Garcia-Regueiro, J.A.;Hair analysis for veterinary drug monitoring in livestock production. *J. Chrom.*, B. 834: 14-25, 2006

Hathcock, J.N.;Quantitative evaluation of vitamin safety. *Pharmacy Times*, 104-113, 1985

Huang, Y and Chen, H.; Studies on the pathogenesis of Shimao Zheng (fleece-eating) in sheep and goats. Vet Res Com 25, 631-40, 2001

Jadwiga, T and Wanda, K .; Influence Of Horse BreedAnd Housing System on the Levelof Selected Elementsin Horse's hair. J. Elem. S. 287–295, 2013

Kaproñ, B., Nowakowicz-Dêbek, B., Wnuk, W., Martyna, J., Saba, L and Ró¯añski, P.; *Effect of living conditions on heavy metal contents in Polish Konik horses coat hair and blood serum*. *Ochr. OErod. Zas. Nat*., 44: 66-71, 2010

Kołacz R, Bodak E, Dobrzański Z, and Patkowska-Sokoła, B.;Trace elements in the wool of Polish merino sheep grazed in polluted and unpolluted environment. Czech J Anim Sc. 44, 509-14, 1999

Krośnicka-Bombała, R.; Influence of a season of the year and a colour on pigment and microelements content in a coat of differently coloured sheep and goats. *ZeszNaukPrzegHod PTZ* 23, 117-32, 1996 [in Polish]

Maia, L., DE Souza, M.V., Braganca, R., Fernandes, A., Fontes, M.P.F., DE Souza Vianna, M.W., Luz, W.V;.Heavy metals in horse blood, serum and feed in Minas Gerais. Brazil. J. Equine Vet. Sci., 26(12): 578-583, 2006

McDowell, L.R.; Vitamin in animal nutrition. Comparative aspect to human nutrition. Academic Press. Pp 93 – 131, 1989

Milad, K., Racz, O., Sipulova, A., Bajova,V and Kovak, G.; Effects of vitamin E and selenium on blood glutathione peroxidase activity and some immunological parameters in sheep. Vet. Med. Czech. 46 (1): 1 – 5, 2001

National Research Council (NRC).; *Food and Nutrition Board Recommended DietaryAllowances* (10th Edn). National Academy Press. Washington DC.,1989

Nieman, D.C., Butterworth, D.E and Nieman, C.N.; Nutrition. Dubuque, Wm. C. Brown Publishers, 1992

Patkowska-Sokoła B, Dobrzański Z, Bodak E, Panyiotu P and Kołacz, R.; Comparative study on the concentration of elements in the wool of sheep of Cyprus and Poland origin. Chem Agric 4, 182-9, 2003

Patkowska-Sokoła, B., Dobrzański, Z., Osman, K., Bodkowski, R and Zygadlik, K.; The content of chosen chemical elements inwool of sheep of different origins and breeds, ArchivTierzucht, 52,4:410-418, 2009

Pearson, D.; Chemical analysis of foods7th Edn. London, Churchill Livingstone, 1976

Ramirez-Perez, A.H., Buntinx, S.E and Rosiles, R.; Effect of breed and age on voluntary intake and the micromineral status of non-pregnant sheep. Micromineral status. Small Rumin Res. 37, 231-42, 2000

Robbins, C.R.; Chemical and physical behavior of human hair, Berlin Heidelberg, Springer-Verlag, 2012

Ryder, M. L.; Nutritional factors influencing hair and wool growth. In: Montagna W, Eliss RA, eds. The Biology of Hair Growth. New York: Academic Press, 305–306, 1958

Scott, G.; The Sheepman's Production Handbook, 4th Edn. USA. AbeggPrinting, 1991

Stachurska, A., Wa£kuska, G., Cebera, M., Jaworski, Z. and Cha£abis-Mazurek, A.; Heavy metal status of Polish Konik horses from stable-pasture and outdoor maintenance systems in the Masurian environment. J. Elem., 16(4): 623-633, 2011

Steel, R.G.D and Torrie, J.H.; Principles and procedures of statistics. London McGraw-Hill, 1960

Sztych, D and Soroczyńska, M.; Some chosen macro- and microelements in the wool of sheep in different stages of lactation. Ann Warsaw AgricultUniv - SGGW, *Anim Sci*. 32, 47-53, 1994

Varian Australia Pty Ltd.; "Introducing Atomic Absorption Analysis. Publication Australia, No. 8510084800, 1997

Varian Techtron.; *Basic atomic absorption spectroscopy- a modern introduction*. Victoria, Dominica Press, 1975

Watts, D. L.; HTMA mineral ratios: A brief discussion of their clinical importane. Trace Elements Newsletter, Vol.21 (1), 2010