DETERMINATION OF IONS AND IRON CONTENT IN HYDATID CYSTS OF *ECHINOCOCCUS GRANULOSUS* ISOLATED FROM DIFFERENT INTERMEDIATE HOSTS (SHEEP, GOATS, CATTLE AND HUMAN) TISSUES

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(Accepted for publication: August 28, 2013)

Abstract

This study included comparative biochemical composition of hydatid fluid, protoscolices, infected and non-infected tissues isolated from liver and lungs of infected sheep, goats, and cattle in Duhok abattoirs during the period from Nov. 2009 to Apr. 2010. Also hydatid fluid of cysts surgically removed from humans in Azadi Teaching Hospital, Duhok during the period from Mar. 2010 to Jul. 2010.Hydatid cysts and host tissues were analyzed for Ions (Na^+, K^+, Ca^{++}, and Mg^{++}) and Fe^{++}. Among Ions, Na+ exhibited high levels in hydatid fluid of the studied hosts with the highest being in hydatid fluid of sheep liver cyst (356±8.207 mg/dl); furthermore, infected tissues showed higher Na^+ levels with the highest being in sheep liver and lung tissues (196±7.461 and 178±5.868 mg/100g respectively). Protoscolices of both liver and lungs showed high K^+ levels, among tissues, infected tissue contained high K^+ levels with the highest being in infected lung tissues (Ranged from 63.46±0.597 mg/100g to 77.39±0.729 mg/100g). Nearly similar levels of Ca^{++} were detected in hydatid fluid and protoscolices of all cysts with the highest level being in goats cysts protoscolices (Liver: 9.212±0.081 mg/100g, Lungs: 9.044±0.072 mg/100g) and the lowest in cattle cysts fluid (Liver: 6.954±0.061 mg/dl, Lungs: 6.826±0.054 mg/dl). The level of Mg^{++} was low in hydatid cysts and tissues of all hosts (Ranged from 0.746±0.016 mg/100g to 0.952±0.015). Small quantities of iron were detected in hydatid cysts of all hosts which were higher in cattle liver cysts (Hydatid fluid 0.0882±0.003 mg/dl and protoscolices 0.0838±0.003 mg/100g) and infected liver tissues (0.2293±0.008 mg/100g).

KEYWORDS: *Echinococcosis, Echinococcus granulosus, HCs chemical composition, Ions, Iron.*

NTRODUCTION

Hydatid disease, Hydatidosis or Cystic Echinococcosis (CE) is a major parasitic disease of veterinary and public health importance throughout the world. This disease has a great economic and zoonotic importance because it affects almost all the domestic animals and human (Baswaid, 2007 and Surhio *et al*., 2011).

Cystic Echinococcosis is caused by the larval stage (Metacestod) of the dog tapeworm *Echinococcus granulosus* by ingesting eggs, which passed with the feces of the definitive hosts, usually feral dogs (Rahimi *et al*., 2011). Humans become infected accidentally through ingestion of eggs, mainly children who are often found infected, because of their closer contacts with dogs (Eckert and Deplazes, 2004).

The distribution of CE is normally associated with underdeveloped countries, especially in rural communities, where man maintains close contact with the dog, the definitive host and various domestic animals which may act as intermediate hosts (Eslami and Hosseini 1998). The larval form of *E. granulosus* in the intermediate host is characterized by its cystic aspect and behaves as a benign tumor in most of the cases (Amman and Eckert, 1996). The cysts may be single or multiple; their main locations are the liver and the lungs; however any other tissue or organ may be involved, including brain, bone, spleen, kidney, …etc. (Moro and Schantz, 2009).

There are seven species of *Echinococcus*, four of them are infectious to human, namely *E. granulosus, E. multilocularis, E. oligartharus* and *E. vogeli* (WHO,2001).

However *E. granulosus*, is the most prevalent species in all continents, causing considerable public health problems in many regions of the world (WHO, 2001). Furthermore, it is also common in Iraq (Al-Fatalawei, 2002 and Al-Nakeeb, 2004), including Kurdistan region (Ghaffar, 2008; Abdullah, 2010 and Meerkhan, 2011).

Epidemiological situation for this parasite is complicated by the fact that several strains have been identified in most area where infection is endemic. These strains exhibit different degrees of infectivity for certain intermediate hosts. Previously, strains were identified using morphological, biological, biochemical and

some other criteria. However, in recent years molecular techniques have contributed in more precise strain identification at the DNA level (Thompson and McManus, 2001).

Most of the studies on this parasitic disease focus either on the veterinary and zoological aspects of the parasite life cycles or on the prevention and control measures or on the medical aspects of the diseases and the treatment options in humans. The information about the mode of parasite nutrition which is somewhat ignored can help us to get some information which might lead the specialists in future to discover some drugs which can be used for treatment of inoperative cyst through their adherence to the biological materials that promote penetration of the drugs to the cyst (Rahdar *et al*., 2008).

This study proposed to determine the chemical components of hydatid cyst (fluid, protoscolices) of cysts isolated from liver and lung tissues of various intermediate hosts, in addition to infected and noninfected host tissues.

MATERIALS AND METHODS

Materials:- The present study include biochemical study on 38 fertile hydatid cysts isolated from the liver and Lungs of infected sheep, goats and cattle slaughtered at Duhok abattoir (Table 1) during the period between November 2009 to April 2010. In addition, 8 hydatid cyst fluids aspirated from humans during surgical removal of cysts from patients at Azadi Teaching Hospital in Duhok city during the period from March 2010 to July 2010. Samples were collected carefully and kept in cool box containing crushed ice and transported to Parasitology laboratory of College of Education, University of Zakho.

Table (1): The number of samples used in this study from different sources

Host	Liver	Lungs	Total
Sheep	5	5	10
Cattle	5	5	10
Goats	5	5	10
Human	4	4	8
Grand Total	19	19	38

Excision of the cyst from infected organs: The cyst was removed from the infected organ and transferred to a crystallizing basin, washed several times with physiological buffer solution (PBS) (pH 7.4) then opened and the cyst content was transferred to a clean container, then the sample was subjected to the following protocol.

Diagnosis of fertile cysts: - All cysts were checked by microscope (40X and 100X) to select the fertile cysts.

Digestion solution: - Was prepared by mixing equal volumes of H2So4 and HNo3 (Saeed and Al-Habbib, 1990). Used for digesting of tissues and protoscolices for determination of minerals.

Sample preparation:- For mineral determination, hydatid cyst fluid, protoscolices and host tissue samples were processed fluid as follow:

1- Hydatid fluid (HF): The HF of each sample was centrifuged at 4000 rpm for 20 minutes. Two ml of the supernatant was completed to 10 ml with deionized water. The sample was refrigerated until use.

2- Tissue and protoscolices: Three ml of digestion solution (1:1 H_2So_4 : HNo_3) was added to 1g of the tissue or protoscolices, left for 48 hr for complete digestion. The aliquot was diluted to 10 ml using deionized water, the sample was Millipore filtered and refrigerated until used. The studies parameters were determined using proper Biolabo-Reagents, France) according to manufacturer instructions.

Statistical analysis: One way analysis of variance (ANOVA) was used for statistical analysis and for comparison between the results (Cohen, 2003).

RESULTS

The level of Ions in hydatid cysts isolated from sheep liver and lungs along with both infected and non-infected sheep liver and lung tissues are shown in Table (2). It is obvious from the table that HFof cysts isolated from sheep liver contained the highest concentration of sodium which was 356±8.207 mg/dl followed by HF of lung cysts (336±6.454 mg/dl). While Na^+ concentration of protoscolices isolated from sheep liver and lung was much lower as compared with HF, and it is ranged from 188±7.427 to 171±5.842 mg/100g, respectively. However, the concentrations of Na^+ in infected and non-infected liver and lungs were intermediate as compared with hydatid cysts; furthermore, infected tissues (liver and lungs) showed higher sodium levels as compared with non-infected with the highest being in liver tissues (Table 2).

Table (2): Ions contents of hydatid cyst, infected and non-infected sheep liver and lung tissues (N: 5).

Parameters	Organ	Hydatid fluid (mg/dl)	Protosco-lice (mg/100g)	Infected tissue (mg/100g)	Non-infect-ed tissue (mg/100g)
Sodium	Liver	356 ± 8.207	188 ± 7.427	196 ± 7.461	160 ± 7.294
	Lung	336 ± 6.454	171 ± 5.842	178 ± 5.868	143 ± 5.736
Potassium	Liver*	39.84 ± 0.335	106 ± 0.894	83.66 ± 0.703	73.3 ± 0.618
	Lung*	36.85 ± 0.347	98.39 ± 0.926	77.39 ± 0.729	67.8 ± 0.64
Calcium	Liver	6.32 ± 0.056	6.824 ± 0.061	6.508 ± 0.057	6.954 ± 0.061
	Lung	6.206 ± 0.048	6.7 ± 0.052	6.39 ± 0.052	6.826 ± 0.054
Magnesium	Liver	0.778 ± 0.017	0.878 ± 0.02	0.858 ± 0.02	0.938 ± 0.02
	Lung	0.792 ± 0.013	0.896 ± 0.015	0.87 ± 0.014	0.952 ± 0.015
Iron	Liver*	0.088 ± 0.003	0.0836 ± 0.003	0.2288 ± 0.008	0.2816 ± 0.01
	Lung*	0.0786 ± 0.002	0.0747 ± 0.002	0.2044 ± 0.004	0.2515 ± 0.006

Protoscolices of cysts isolated from sheep liver and lungs showed the highest concentration of potassium which was greater by about 2.7 folds as compared with HF of the same cysts. Regarding host tissues, both infected liver and lungs tissues showed higher potassium concentration as compared with non-infected tissue with the highest being in lung tissues (Table 2). With respect to Calcium and Magnesium ions, their concentrations were almost the same in hydatid cysts, infected and non-infected liver and lung tissues as indicated in Table (2).

Very little amount of iron was detected in HF and protoscolices of both liver and lungs cysts. On the other hand, infected and non-infected liver and lung tissues showed higher concentration of iron as compared with hydatid cysts and this difference was statistically significant ($P \leq 0.05$). In conclusion, there was a wide variation in the concentration of the four different ions in the protoscolices and HF. Sodium was higher in HF, whereas, K^+ level were higher in protoscolices.

The level of Ions in hydatid cysts isolated from goats liver and lungs along with both infected and non-infected goats liver and lung tissues are shown in Table (3). It is obvious from the table that HF of cysts isolated from goats liver contained the highest concentration of sodium which was 220±7.576 mg/dl followed by HF of lung cysts (202±5.958 mg/dl). While, Na^+ concentration of protoscolices isolated from goats liver and lung was much lower as compared with HF, and it is ranged from 66.07±6.856 to 49.85±5.391 mg/100g, respectively.

However, the concentration of Na^+ in infected and non-infected tissues was much lower as compared with hydatid cysts (Table 3). But infected tissues (both liver and lungs) showed higher Na^+ levels than non-infected tissues. Generally Na^+ levels were higher in liver cyst, infected and non-infected tissues as compared with correspondent lung cysts and tissues.

Table (3): Ions contents of hydatid cyst, infected and non-infected goats liver and lung tissues (N: 5).

Parameters	Organ	Hydatid fluid (mg/dl)	Protosco-lice (mg/100g)	Infected tissue (mg/100g)	Non-infect-ed tissue (mg/100g)
Sodium	Liver	220 ± 7.576	66.07 ± 6.856	72.75 ± 6.887	39.95 ± 6.734
	Lung	202 ± 5.958	49.85 ± 5.391	56.46 ± 5.416	24.02 ± 5.296
Potassium	Liver*	36.65 ± 0.309	97.86 ± 0.823	76.97 ± 0.647	67.44 ± 0.567
	Lung*	33.9 ± 0.318	90.52 ± 0.853	71.19 ± 0.67	62.38 ± 0.588
Calcium	Liver	8.534 ± 0.076	9.212 ± 0.081	8.788 ± 0.076	9.384 ± 0.083
	Lung	8.374 ± 0.067	9.044 ± 0.072	8.63 ± 0.069	9.214 ± 0.072
Magnesium	Liver	0.678 ± 0.016	0.766 ± 0.016	0.746 ± 0.016	0.814 ± 0.018
	Lung	0.692 ± 0.01	0.778 ± 0.012	0.758 ± 0.012	0.828 ± 0.012
Iron	Liver*	0.083 ± 0.003	0.0789 ± 0.003	0.2158 ± 0.008	0.266 ± 0.01
	Lung*	0.0736 ± 0.002	0.0699 ± 0.002	0.1914 ± 0.004	0.236 ± 0.006

Protoscolices of cysts isolated from goats liver and lungs showed the highest concentration of potassium which was about 2.65 folds as compared with HF of the same cysts. Regarding host tissues, both infected liver and lungs tissues showed higher potassium concentration as compared with non-infected tissue (Table 3), and these differences were statistically significant ($P \leq 0.05$).

With respect to Calcium and Magnesium, their concentrations were almost the same in hydatid cysts, infected and non-infected host tissues as indicated in Table (3).

Very small amount of iron was detected in HF and protoscolices of both liver and lungs cysts. On the other hand, infected and non-infected liver and lung tissues showed higher concentrations of iron as compared with hydatid cysts and this difference was statistically significant ($P \leq 0.05$).

The level of Ions in hydatid cysts isolated from cattle liver and lungs along with both infected and non-infected cattle liver and lung tissues are shown in Table (4). HF of cysts isolated from cattle liver contained the highest concentration of sodium which was 238±7.659 mg/dl followed by HF of lung cysts (220±6.024 mg/dl). While Na^+ concentration of protoscolices isolated from cattle liver and lung was much lower as compared with HF, and it is ranged from 82.39±6.931 to 66±5.45 mg/100g, respectively. However, the concentration of Na^+ in infected and non-infected tissues was intermediate as compared with hydatid cysts (Table 4). Liver cysts and infected liver tissues showed higher Na^+ levels.

Table (4): Ions contents of hydatid cyst, infected and non-infected cattle liver and lung tissues (N: 5).

Parameters	Organ	Hydatid fluid (mg/dl)	Protosco-lice (mg/100g)	Infected tissue (mg/100g)	Noninfect-ed tissue (mg/100g)
Sodium	Liver	238 ± 7.66	82.39 ± 6.931	89.14 ± 6.963	55.99 ± 6.808
	Lung	220 ± 6.024	66 ± 5.45	72.67 ± 5.475	39.88 ± 5.354
Potassium	Liver*	32.67 ± 0.274	87.22 ± 0.732	68.6 ± 0.578	60.11 ± 0.506
	Lung*	30.22 ± 0.284	80.68 ± 0.759	63.46 ± 0.597	55.6 ± 0.523
Calcium	Liver	6.954 ± 0.061	7.51 ± 0.07	7.158 ± 0.063	7.648 ± 0.066
	Lung	6.826 ± 0.054	7.37 ± 0.06	7.03 ± 0.055	7.51 ± 0.06
Magnesium	Liver	0.71 ± 0.016	0.80 ± 0.018	0.78 ± 0.016	0.85 ± 0.018
	Lung	0.722 ± 0.01	0.816 ± 0.012	0.794 ± 0.012	0.866 ± 0.012
Iron	Liver*	0.088 ± 0.003	0.084 ± 0.003	0.23 ± 0.008	0.282 ± 0.009
	Lung*	0.08 ± 0.001	0.076 ± 0.001	0.209 ± 0.003	0.257 ± 0.004

Protoscolices of cysts isolated from cattle liver and lungs showed the highest concentration of potassium which was about 2.65 folds as compared with hydatid fluid of the same cysts. Regarding host tissues, both infected liver and lungs tissues showed higher potassium concentration as compared with non-infected tissue, with the highest levels being in liver cyst and tissues (Table 4).

With respect to Calcium and Magnesium, their concentrations were almost the same in hydatid cysts, infected and non-infected host tissues as indicated in Table (4).

Very small amount of iron was detected in HF and protoscolices of both liver and lungs cysts. On the other hand, infected and non-infected liver and lung tissues showed higher concentration of iron as compared with hydatid cysts and this difference was statistically significant ($P \leq 0.05$). Regarding tissues, liver tissues showed slightly higher Fe^{++} levels than lung tissues.

The level of Ions in HF of cysts removed from human liver and lungs are shown in Table (5). It is obvious from the table that HF of liver cysts contained the highest concentration of sodium which was 191±7.768 mg/dl followed by HF of lung cysts (180±7.02 mg/dl).

The HF of cysts removed from human liver contained the highest concentration of potassium which was 31.76 ± 0.153 mg/dl, followed by HF of lung cysts (29.44 ± 0.353 mg/dl). This deference was statically significant ($P \leq 0.05$).

Table (5): Ions contents of hydatid fluid of cysts removed from human (mg/dl) (N: 4).

Parameters	Liver	Lung	Normal values
Sodium	191 ± 7.768	180 ± 7.02	92-500
Potassium	31.76 ± 0.153	29.44 ± 0.353	98-470
Calcium	7.943 ± 0.073	7.76 ± 0.08	100-300
Magnesium	0.74 ± 0.015	0.763 ± 0.02	68.02-97.50
Iron	0.09 ± 0.003	0.078 ± 0.002	0.045-0.16

With respect to Calcium and Magnesium, their concentrations were almost the same in HF of both liver and lung cysts as indicated in Table (5).

Very small amount of iron was detected in HF of both liver and lung cysts which was slightly higher in liver cyst HF, and deference was statically non-significant (P> 0.05).

Table (6) shows comparison between the ion contents of hydatid cysts isolated from liver of various intermediate hosts. Regarding the Ions, there are some differences in their levels in HF and protoscolices of different intermediate hosts. HF of all hosts contained the higher levels of Na^+ than protoscolices, with the highest being in HF of sheep cysts (356 ± 8.207 mg/dl). On the other hand, protoscolices contained higher levels of K^+ ions, also the highest being in sheep cysts.

Table (6): Comparison between ion contents of hydatid cysts isolated from livers of different hosts.

Parameters	Sheep (N:5)		Goat (N:5)		Cattle (N:5)		Human N:4)
	Hydatid fluid (mg/dl)	Protos-colices (mg/100g)	Hydatid Fluid (mg/dl)	Protos-colices (mg/100g)	Hydatid Fluid (mg/dl)	Protos-colices (mg/100g)	Hydatid Fluid (mg/dl)
Sodium	356 ± 8.207	188 ± 7.427	220 ± 7.576	66.1 ± 6.856	238 ± 7.659	82.39 ± 6.931	191 ± 7.768
Potassium	39.8 ± 0.335	106 ± 0.894	36.7 ± 0.309	97.86 ± 0.823	32.67 ± 0.274	87.22 ± 0.732	31.8 ± 0.153
Calcium	6.32 ± 0.056	6.82 ± 0.061	8.53 ± 0.076	9.21 ± 0.081	6.954 ± 0.061	7.508 ± 0.066	7.943 ± 0.073
Magnesium	0.78 ± 0.017	0.88 ± 0.02	0.68 ± 0.016	0.77 ± 0.016	0.71 ± 0.016	0.802 ± 0.018	0.74 ± 0.015
Iron	0.09 ± 0.003	0.08 ± 0.003	0.08 ± 0.003	0.079 ± 0.003	0.088 ± 0.003	0.084 ± 0.003	0.09 ± 0.003

With respect to Ca^{++}, almost there was no difference in its level in HF and protoscolices, regarding hosts, the highest level observed in goats HF and protoscolices, while the lowest level was in sheep. Both HF and protoscolices in all hosts contain low levels of Mg^{++} (Table 6).

Small quantities of iron were detected in hydatid cyst which was slightly higher in liver cysts as compared with lung cysts (Tables 6 and 7).

Table (7): Comparison between ion contents of hydatid cysts isolated from lungs of different hosts.

Parameters	Sheep (N:5)		Goat (N:5)		Cattle (N:5)		Human N:4)
	Hydatid fluid (mg/dl)	Protos-colices (mg/100g)	Hydatid Fluid (mg/dl)	Protos-colices (mg/100g)	Hydatid Fluid (mg/dl)	Protos-colices (mg/100g)	Hydatid Fluid (mg/dl)
Sodium	336 ± 6.454	171 ± 5.842	202 ± 5.96	49.85 ± 5.391	220 ± 6.024	66 ± 5.45	180 ± 7.02
Potassium	36.85 ± 0.347	98.4 ± 0.926	33.9 ± 0.318	90.52 ± 0.853	30.2 ± 0.284	80.68 ± 0.759	29.44 ± 0.353
Calcium	6.206 ± 0.048	6.7 ± 0.052	8.37 ± 0.067	9.044 ± 0.072	6.83 ± 0.054	7.37 ± 0.06	7.76 ± 0.08
Magnesium	0.79 ± 0.013	0.9 ± 0.015	0.69 ± 0.01	0.778 ± 0.012	0.72 ± 0.01	0.82 ± 0.012	0.763 ± 0.02
Iron	0.079 ± 0.002	0.075 ± 0.002	0.074 ± 0.002	0.07 ± 0.002	0.08 ± 0.001	0.076 ± 0.001	0.078 ± 0.002

DISCUSSION

Differences in the metabolism of hydatid cyst from different intermediate hosts such as sheep, goats, cattle camels and human is most probably due to complex geographical strains as well as their biochemical and physiological differences (Frayha and Haddad, 1980; McManus, 1981; and Refik, *et al*., 2002). Thus, wide variations in the concentrations of ions and other chemicals have been reported by Frayha and Haddad (1980). Since Na^+ is the major extracellular cation, the highest Na^+ concentrations was observed in HF, while, comparatively, a lower Na^+ concentration was exhibited by protoscolices. On the other hand, since K^+ is the major intracellular cation, highest K^+ concentration was observed in protoscolices which is about 2.7 folds as compared with HF. High cation concentration in protoscolices may be due to the presence of cation-rich calcareous corpuscles present in the tissue (Frayha and Haddad, 1980).

Also high NaCl concentration is the characteristics of the body fluid of ecto- and endoparasites (Von, 1979) as well as the hydatid cyst fluid (Frayha and Haddad, 1980).

The concentration of Ca^{++} was much lower than Na^+ and K^+ ions. Furthermore, Ca^{++} concentration in HF and protoscolices in goats was slightly higher as compared with others, and the lowest was exhibited by cattle. Radfar and Iranyar (2004) also reported such a low level of Ca^{++} in the HF of sheep, goats, cattle and human cysts. The presence of Ca^{++} in the hydatid cyst fluid is of vital importance since it prevents the hydatid cyst fluid acidity and its accumulation as calcareous body in the cyst (Rahdar *et al*., 2008).

The concentration of Mg^{++} was much lowers than Ca^{++} ion concentration. Since Mg^{++} has narcotics action on the body activities, it is usually excreted to the exterior via conventional transport mechanisms (Bernath *et al*. 1985).

However, in the current study, sheep, goats and cattle hydatid cyst, showed comparatively slightly higher Ca^{++} and Mg^{++} levels in protoscolices than hydatid cyst fluid. This agrees with the results of Frayha and Haddad, (1980) who indicated that the amount of Ca^{++} and Mg^{++} in protoscolices were more than that of hydatid fluid.

Since there are no detailed systematic studies on comparative biochemical composition in hydatid cysts from different hosts (sheep, goats, cattle, camel and human), it is very difficult to compare the results. However, there is a general tendency of cations of physiological importance (Na^+ and K^+) to exhibit the highest levels in sheep among the studied animals. On the other hand, the lowest levels of Na^+ and K^+ were observed in human hydatid cyst fluid.

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الخلاصة

تضمنت هذه الدراسة مقارنة بين المكونات الكيموحياتية للاكياس المائية (السائل العدري والرؤوس البدائية) إضافة الى الانسجة المصابة وغير المصابة المعزولة من كبد ورئتي الاغنام والماعز والماشيه المذبوحة في مجزرة دهوك للفترة من تشرين الثاني ٢٠٠٩ الى نيسان ٢٠١٠. إظافة الى عينات سائل الاكياس المائية المستأصلة من المصابين في مستشفى آزادي التعليمي في دهوك للفترة من آذار ٢٠١٠ الى تموز ٢٠١٠. وقد تمت دراسة مستوى الآيونات (Na^+, K^+, Ca^{++}, and Mg^{++}) والحديد Fe^{++} في الاكياس المائية والانسجة المصابة للمضائف المختلفة.

من بين الآيونات أظهر آيون الصوديوم Na^+ مستويات عالية في السوائل العدرية للاكياس المأخوذة من مختلف المضائف مع ارتفاع ملحوظ في اكياس اكباد الاغنام المصابة (٣٥٦±٨،٢٠٧ ملغم/ديسيلتر). كذلك فإن الانسجة المصابة أظهرت مستويات عالية من آيون الصوديوم مع ارتفاع ملحوظ في اكياس اكباد ورئات الاغنام المصابة (١٩٦±٧،٤٦١ ملغم/ديسيلتر و ١٧٨±٥،٨٦٨ ملغم/ديسيلتر على التوالي).

الرؤوس البدائيةلاكياس الاكباد والرئات المصابة أظهرت مستويات عالية من آيون البوتاسيوم +K . ومن بين الانسجة، اظهرت الانسجة المصابة مستويات عالية منه مع ارتفاع ملحوظ في الرئات (من: ٠،٥٩٧±٦٣،٤٦ ملغم/١٠٠غم الى: ٠،٧٢٩±٧٧،٣٩ ملغم/١٠٠غم).

وجدت مستويات عالية تقريبا من آيون الكالسيوم ++Ca للسائل العدري والرؤوس البدائية للاكياس المائية مع ارتفاع ملحوظ في السائل العدري للاكياس المستاصلة من انسجة الماعز (كبد: ٠،٠٦١±٦،٩٥٤ ملغم/ديسيلتر, رئات: ٠،٠٥٤±٦،٨٢٦ ملغم/ديسيلتر). أما بالنسبة لمستوى المغنسيوم ++Mg، فكان واطئا في اكياس وانسجة جميع المضائف (من: ٠،٠١٦±٠،٧٤٦ ملغم/١٠٠غم الى: ٠،٠١٥±٠،٩٥٢ ملغم/١٠٠غم).

كميات قليلة من الحديد ++Fe وجدت في اكياس جميع المضائف، مع ارتفاع طفيف في اكباد الماشية (السائل العدري: ٠،٠٠٣±٠،٠٨٨٢ ملغم/ديسيلتر والرؤوس البدائية:٠،٠٠٣±٠،٠٨٣٨ ملغم/١٠٠غم ونسيج الاكباد المصابة: ٠،٠٠٨±٠،٢٢٩٣ ملغم/١٠٠غم).

پوختە

دڤێ ڤەکولینێ دا، بەراوەردکرەنکا بایوکیمیایی هاتە کرن دناڤبەرا کیسکێت ئاڤێ (ئاڤا کیسکا و سەرکێت دەستپێکی) زێدەباری پوشەکێت ئێشگرتی و پێت ساخلەم پێت مێلاك وپشێت پەز وبزن وچێلێت هاتینە سەر ژێکرن ل سەرژێگەها دهوك دناڤبەرا چریا دووێ ٢٠٠٩ هەتا نیسان ٢٠١٠. هەروەسا چەند نمونەك ژ کیسکێت ئاڤێ پێت کو هاتینە ژێڤەکرن ژ نەخوشێت نەخوشخانا ئازادی یا فێرکرنێ دناڤبەرا ئادار٢٠١٠ الی تیرمەه ٢٠١٠. ودڤێ ڤەکولینێ دا ئاستێت ئایونێت (Na^+, K^+, Ca^{++}, and Mg^{++}) وئاسنی Fe^{++} دکیسکێت ئاڤێ و پوشەکێت ئێشگرتی پێت خانەخوپێت جورەوجور هاتنە خواندن.

دناڤ ئایونا دا، ئایونێ صودیومی Na^+ ئاستەکێ بلند دیار کر د ئاڤا کیسکێت وەرگرتی دگەل بلندیەکا بەرچاڤ دناڤ کیسکێت مێلاکێت پەزێت ئێشگرتی (٣٥٦±٨,٢٠٧ ملغم/دیسیلتر). هەروەسا پوشەکێت ئێشگرتی ئاستێت بلند دیار کرن ژ ئایونێ صودیومی دگەل بلندیەکا بەرچاڤ د کیسکێت مێلاك وپشێت پەزێت ئێشگرتی (١٩٦±٧,٤٦١ ملغم/دیسیلتر و ١٧٨±٥,٨٦٨ ملغم/دیسیلتر د دویف ئێك دا).

سەرکێت دەستپێکی پێت مێلاك وپشێت ئێشگرتی ئاستەکێ بلند دیار کر ژ ئایونێ پوتاسیومی K^+ . ودناڤ پوشەکا دا، پوشەکێت ئێشگرتی ئاستەکێ بلند دیار کر دگەل بلندیەکا بەرچاڤ دناڤ پشێ دا (ژ: ٠,٥٩٧±٦٣,٤٦ ملغم/١٠٠غم تا: ٠,٧٢٩±٧٧,٣٩ ملغم/١٠٠غم).

ئاستێت بلند ژ ئایونێ کالسیومی Ca^{++} دناڤ ئاڤ وسەرکێت دەستپێکی پێت کیسکێت ئاڤێ دگەل بلندیەکا بەرچاڤ د ئاڤا کیسکێت ژ پوشەکێت بزنا وەرگرتین (مێلاك: ٠,٠٦١±٦,٩٥٤ ملغم/دیسیلتر, پش: ٠,٠٥٤±٦,٨٢٦ ملغم/دیسیلتر). و سەبارەت ئایونێ مگنسیومی Mg^{++}، یێ نزم بو د کیسك وپوشەکێت هەمی خانەخویا دا (ژ: ٠,٠١٦±٠,٧٤٦ ملغم/١٠٠غم تا: ٠,٠١٥±٠,٩٥٢ ملغم/١٠٠غم).

هندەك قەباریت کیم ژ ئاسنی Fe^{++} هاتنە دیتن دناڤ کیسکێت هەمی خانەخویا دا دگەل بلندیەکا کیم دمێلاکێت چێلا دا (ئاڤ: ٠,٠٠٣±٠,٠٨٨٢ ملغم/دیسیلتر سەرکێت دەستپێکی:٠,٠٠٣±٠,٠٨٣٨ ملغم/١٠٠غم وپوشەکێ مێلاکێت ئێشگرتی: ٠,٠٠٨±٠,٢٢٩٣ ملغم/١٠٠غم).