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Free-Water Intake as a Measure of Total Body Water in Cattle

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SIX mature Friesian bulls at average body weight of 562 kg were injected with ^3HOH under ambient temperature of 16° and 60% RH to compare between total body water estimated by extrapolation method either from blood or urine samples and equilibration method from blood samples. A total of 12 blood samples were taken during the period of 2-192 hr post injection. Urine was daily collected at 24-192 hr post injection. Free-water intake was daily measured for 8 days.

The data showed that there was no significant difference in total body water determined from blood (24-192 hr) or from urine (24-192 hr) samples by applying the extrapolation method. However, significant differences ($P<0.05$) were observed in biological halflife and water turnover rate. Insignificant differences in total body water either estimated from one blood sample taking at 2 or 4 hr post injection (equilibration method) and extrapolation method. Therefore, after 2 hr post injection with ^3HOH, the values of total body water and in-vivo body composition (protein, fat and ash) could be obtained instead of waiting 8 days to obtain these information.

Free-water intake was found to be significantly ($P<0.01$) correlated with total body water and water turnover rate. The predicted equations were: 1) Total body water, l = 427.2 — 1.1519 Free-water intake, l and 2) Water turnover rate, l/day = 23.2 + 0.219 Free-water intake, l. Therefore, it is possible to predict water turnover rate, biological half-life, total body water and in-vivo body composition from measuring water intake instead of injecting radioactive material. This would help to measure the daily variation in the abovementioned parameters

Radioactive water (^3HOH) has been commonly used to determine total body water, body composition and water turnover rate (Shebaita *et al.*, 1973, 1975; Pfau and Shebaita, 1980; Shebaita and Elbanna, 1982) by applying the extrapolation method ($A_t = A_0 e^{-\lambda t}$) from blood samples. Many attempts (Macfarlane et al., 1966, 1974) have been made by equilibration method to determine total body water by taking only one blood or urine sample after equilibraicn (6 hr) Although, Pfau and Salem (1972) stated that the extrapolation method is more reliable than equilibration method when ^3HOH is determined in blood. On the other hand, the close value between water turnover rate and water consumption (El-Fouly *et al.*, 1979; Shebaita and Elbanna, 1982) provides

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promising basis for predicting water intake under grazing conditions or when water consumption cannot be recorded. If such relation holds to be true, therefore, it is possible to predict water turnover rate, total body water and in-vivo body composition from measuring water intake instead of injecting radioactive material and consequently increasing contamination. The abovementioned information were the bases for this study.

Material and Methods

Six mature Friesian bulls at average body weight of 562 kg were maintained in controlled climatic barn at 16° and 60% RH. The bulls were prevented from feed and water for 12 hr before the injection with ^{3}HOH as explained by pfau and Shebaita (1980). Blood samples were collected at 2,4,6,12,24 hr. and every 24 hr up to 192 hr (8 days) post injection. Free-water intake and total urine output were measured every 24 hr for 8 days. The counting procedure of radioactive material in serum water or in urine water was done as explained before (Pfau and Shebaita, 1980).

Results and Discussion

Table 1 shows the values of total body water, biological halflife and water turnover rate using the extrapolation method either from serum water or from urine water. The data showed insignificant difference in calculating total body water whether the counting samples were from serum or urine using the extrapolation method (24-192 hr) as shown in Table 2. However, biological half-life was significantly ($P<0.05$) higher and water turnover rate was significantly lower ($P<0.05$) from urine samples compared with serum samples. These finding are in agreement with Macfarlane *et al.* (1974) who pointed out that once equilibration has occurred there is theoretically no difference between the ratio of radioactive hydrogens to the hydrogen molecules in any body fluid. Plasma water, red cell water, tissue fluid, urine or fecal water, tears or milk, respiratory water or sweat should all contain the same ratio. This is not, however, quite strictly true since it is difficult to get a uniform sample of urine when the bladder accumulates different concentraions over the course of some hours. The most useful samples are that taken from blood and both cells and plasma may be used to provide the water for measurement.

It is worthnoting, however , that there were no significant differences in total body water, biological half-life and water turnover rate for the different sampling times from the blood (Tables 1 and 2). Nevertheless, extrapolation method using the whole collected samples (2-192 hr) is recommended because it gives the closest true value of the instantaneous picture of the ratio between radioactive hydrogens and the hydrogen molecules in the body fluid.

Comparison between total body water in Friesian bulls by the equilibration and that estimated by extrapolation method (2-192 hr) are shown in Table 3. Generally, total body water determined by the requilibration at 2 and 4 hr were 4.03% and 1.88%, respectively less than that obtained from the extrapolation method. The values determined by equilibration at 6.12 and 24 hr were 5.29-9.07% higher than that obtained from extrapolation method (Table 3).

TABLE 1. **Total body water (TBW, l.), biological half-life ($B\frac{1}{2}$, hr.) and water turnover rate (WTR, l./day) using extrapolation method.**

Bull	"r"	A_o	k	TBW, l.	$B\frac{1}{2}$, hrs.	WTR, l./day
			Serum samples 2-192 hr			
1	—0.977	2696	—0.00298	373.7	232.6	26.7
2	—0.978	2461	—0.00273	406.3	253.8	26.6
3	—0.980	2400	—0.00284	416.7	244.0	28.4
4	—0.980	2659	—0.00311	376.1	222.8	28.1
5	—0.987	2609	—0.00337	383.3	205.6	31.0
6	—0.967	2643	—0.00344	378.4	201.4	31.2
				389.1 ± 17.96	226.7 ± 20.83	28.7 ± 2.02
			Serum samples 4-192 hr			
1	—0.976	2650	—0.00291	377.4	238.1	26.4
2	—0.979	2483	—0.00280	402.7	247.5	27.1
3	—0.989	2350	—0.00269	425.5	257.6	27.5
4	—0.985	2608	—0.00297	383.4	233.3	27.3
5	—0.988	2576	—0.00328	388.2	211.3	30.6
6	—0.965	2607	—0.00334	383.6	207.5	30.8
				393.5 ± 17.87	232.6 ± 19.81	28.3 ± 1.91
			Se;um Samples 6-192 hr			
1	—0.978	2599	—0.00277	384.8	250.2	25.6
2	—0.982	2439	—0.00267	410.0	259.6	26.3
3	—0.988	2335	—0.00264	428.3	262.5	27.1
4	—0.992	2661	—0.00311	375.8	222.8	28.0
5	—0.997	2512	—0.00310	398.1	223.6	29.6
6	—0.969	2534	—0.00314	394.6	220.7	29.7
				398.6 ± 18.65	239.9 ± 19.66	27.7 ± 1.70

TABLE I. (*Cont*).

Bull	"r"	A_0	K	TKW, l.	B, hr	WTR, l./day
			Serum samples 12-192 hr			
1	—0.973	2582	—0.00273	387.3	253.8	25.4
2	—0.979	2453	—0.00271	407.7	255.7	26.5
3	—0.986	2342	—0.00266	427.0	260.5	27.3
4	—0.991	2668	—0.00313	374.8	221.4	28.2
5	—0.997	2531	—0.00315	395.1	220.0	29.9
6	—0.965	2562	—0.00322	390.3	215.2	20.2
				397.0 ± 18.17	237.8 ± 20.92	27.9 ± 1.89
			Serum samples 24-192 hr			
1	—0.965	2595	—0.00276	385.4	251.1	25.5
2	—0.989	2542	—0.00296	393.4	234.1	27.9
3	—0.990	2401	—0.00283	416.5	244.9	28.3
5	—0.989	2698	—0.00321	28.6	211.9	211.9
6	—0.998	2574	—0.00327	388.5	370.6	30.5
6	—0.958	2602	—0.00333	384.3	208.1	30.7
				389.8 ± 15.14	227.7 ± 18.21	28.6 ± 1.91
			Urine samples 24—192 hr			
1	—0.916	2670	—0.00289	374.5	239.8	26.0
2	—0.874	2376	—0.00231	420.9	300.0	23.3
3	—0.875	2438	—0.00264	410.2	262.5	26.0
4	—0.960	2690	—0.00268	371.7	258.6	23.9
5	—0.958	2378	—0.00236	420.5	293.6	23.8
6	—0.936	2640	—0.00312	378.8	222.1	28.4
				396.1 ± 23.54	262.8 ± 30.12	25.2 ± 1.94

TABLE 2. Test of significance.

Item	TBW	$B\frac{1}{2}$	WTR
Serum 2—192 × 4-192	NS	NS	NS
Serum 2—192 × 6-192	NS	NS	NS
Serum 2—192 × 12-192	NS	NS	NS
Serum 2—192 × 24-192	NS	NS	NS
Serum 2—192 × urine 24-192	NS	<0.05	<0.05
Serum 4—192 × 6-192	NS	NS	NS
Serum 4—192 × 12-192	NS	NS	NS
Serum 4—192 × 24-192	NS	NS	NS
Serum 4—192 × urine 24-192	NS	<0.10	<0.10
Serum 6—192 × 12-192	NS	NS	NS
Serum 6—192 × 24-192	NS	NS	NS
Serum 6—192 × urine 24-192	NS	NS	<0.05
Serum 12—192 × 24-192	NS	NS	NS
Serum 12—192 × urine 24-192	NS	NS	<0.05
Serum 24—192 × urine 24-192	NS	<0.05	<0.05

NS not significant

The insignificant lower total body water values by equilibration at 2 and 4hr compared with the extrapolation is due to the fact that tritiated water(^{3}HOH) takes at least 6 hr to equilibrate with rumen water (Till and Downes, 1962 ; Kamal and Seif, 1969 and Macfarlane *et al.*, 1974). However, equilibration at 2 and 4 hr in this study measure about 96-98% of the total body water. In this respect, Macfarlane *et al.* (1969), Searle (1970) and Kamal (1979) found that sampling 1-4 hr after dosing permits to measure about 96-98 % of the total body water in cattle, sheep and goats, including their rumen water. On the contrary, El-Fouly *et al.* (1979) found a uniform distribution of ^{3} HOH activity in blood and ruminal water sub-pools was noticed approximately 12-18 hr after injection. Also ^{3} HOH specific activity in the rumen reached 90-95% of that in the blood at 8 hr post injection. While Macfarlane (1965) and Macfarlane and Howard (1966) used a 6 hr sample to calculate total body water, Macfarlane *et al.* (1967) used one 24 hr sample for such calculation.

It is admitted, however, that the extrapolation method yields a true total body water from a biodecay curve. Besides, it gives the possibility of computing water turnover rate and biological half-life Equilibration method has more advantage for not depriving the animals from feed and water for 6-8 hr.

especially under hot climate. So the animals do not lose water by vaporization during such a time (2 or 4 hr). Moreover, the disadvantage of radioactive hydrogen exchange with tissue hydrogen and the physiological systems in the body are not disturbed by such a measurement. Above all, after 2-4 hr post injection, the value of total body water and consequently the in-vivo body composition could be obtained instead of waiting at least 8 days to obain these information.

TABLE 3. **Total body water using equilibration method.**

Bull	TBW, l. using equilibration at				
	2 hr	4 hr	6 hr	12 hr	24 hr
1	360.9	357.0	385.2	403.6	379.9
2	424.6	383.1	422.5	447.6	419.8
3	382.7	420.5	438.6	459.8	445.2
4	347.9	415.8	385.4	396.7	388.5
5	365.2	361.1	413.1	422.3	421.1
6	359.3	353.0	413.5	416.5	412.7
	373.4	381.8	409.7	424.4	411.2
	± 27.50	± 30.09	± 21.05	± 24.73	± 23.77
2-192 hrs	NS	NS	—0.10	<0.05	<0.10

NS not significant

Table 4 shows the averages of free-water intake for each bull. Simple linear relationships between free-water intake and either total body water or water turnover rate using extrapolation method (2-192hr.) were found to be significant ($P<0.01$). The comparison between free-water intake and water turnover rate have been studied by many investigators and found that water turnover rate is similar to water consumption in cattle, sheep and goats (Macfarlane *et al.*, 1974; El-Fouly *et al.*, 1979; Shebaita and Elbanna, 1982).

Unfortunately, no data are available on the relationship between free-water intake and total body water for comparison. However, this relationship should be exist. In this respect, Strauss (1957) has shown that thirst could be stimulated by many factors such as extracellular fluid deficiency, concentration of the intracellular body fluid, body water deficit and/or the hypertonicity of the extracellular fluid. However, most of these factors though different in nature still prove that thirst is stimulated through one main factor, which is the decrease in total body water content.

It is advisable to test the relaionship between water intake and total body water under different circumstances. If such relation holds to be true, therefore , it is possible to predict water turnover rate, biological half-life, total body water and in-vivo body composition from measuring water intake instead of injecting radioactive material. This would help to measure the daily variation in the above mentioned parameters.

TABLE 4. **Free-water intake, l. and prediction equations.**

Bull	Free-water intake, l.
1	24.0 ± 2.33
2	23.5 ± 1.20
3	22.0 ± 3.25
4	24.6 ± 2.56
5	25.5 ± 3.85
6	31.0 ± 4.75

Prediction equations

Total body water, l. = 427.2 — 1.519 Water intake, l.
df = 46 "r"—0.383 ($P<0.01$)

Water turnover rate, l./day = 23.2 + 0.219 Water intake, l.
df = 0.491'r" 0.49 ($P<0.01$)

References

El-Fouly, H.A., Elbanna, I.M. and Kamal, T.H. (1979) Estimation of equilibrium time between rumen and blood water using a modified TOH extraction technique in sheep. *Arab. J. Nucl. Sci. & Appl.* **12,** 593,

Kamal, T.H. (1979) The effect of watering system on water turnover rate and body water and the prediction of summer growth rate in farm animals using the tritiated water dilution technique. Paper presented at 4 *th* FAO/IAEA research coordination meeting on Water requirement of tropical herbivores based on measurement with tritiated water. Nairobi, Kenya .

Kamal, T.H. and **Seif, S.M.** (1969) Effect of natural and controlled climates of the Sahara on virtual tritium space in Friesians and water Buffaloes. *J. Dairy Sci.* 52 1657-.

Macfarlane, W.V. (1965) Water metabolism of desert ruminants. Studies in Physiology, SpringerVerlag, 191 —199 .

Macfarlane, W.V. (1966) Howard, B., Water content and turnover of identical twin Bos indicus and B. taurus in Kenya. *J. Agric. Sic.* 66,297- .

Macfarlane, W.V. Howard, B. and **Good, B.F.** (1974) Tracers in field measurements of water, milk and thyroxine metabolism of tropical ruminants. In *Trac. Tech. Trop. Anim. Prod., FAO*/IAEA Pub. 1-23.

Macfarlane, W.V., Howard, B., Morrison, J.F., and Wyndham, C.H. (1966) Conte nt and turnover of water in bantu miners acclimatizing to humid heat. J. *Appl. Physiol.* **21,** 978.

Macfarlane, W.V., Howard, B.and Siebert, B.D. (1969) Tritiated water used to measure intake. of milk and tissue growth of ruminants in the field. *Nature* **221,** 578.

Macfarlane, W.V., Howard, B. and **Siebert, B.D.** (1967) Water metabolism of merino and border leicester sheep grazing saltbush. *Aust. J. Agric. Res.* **18,** 947.

Pfau, A., and Salem, M.A.I. (1972) Studies on body composition of cattle by isotope dilution analysis. *In Isot. Stu. Physiol. Domest. Anim.*, FAO/IAEA Pbu. 21-33 .

Pfau, A. and Shebaita, M.K. (1980) Studies on bodu water in bulls under heat stress. Pape presented at *31th Meeting of Europ. Soc. Anim. Prod.* Munich .

Searle, T.W., (1970) Body composition in lambs and young sheep and its prediction in-vivo from tritiated water space and body weight. *J. Agric. Sci.* **74**, 357.

Shebaita, M.K., Elbanna, **I.M.,** Heat load and heat dissipation in sheep and goats under environmental heat stress. *Zoot. Res.* (In Press).

Shebaita, M.K., El-Fouly, H.A.,and Abou-Akkada, A.R. (1975) Effect of synthetic estrogen on body compartments. *Wld. Rev. Anim. Prod.* **11** 44- .

Shebita, M.K., Seif, S.M.,and Kamal, T.H.(1973)In-vivo body composition in ruminants: 2-New equation for lean body mass. *Alex. J. Agric. Res.* **21** 351-360. .

Strauss, M.B. (1957) *Body Water in Man*, *1st* edn., Brown & Company, Boston-Toronto,

Till, A.R., Downes, A.M. (1962) The measurement of total body water in the sheep. *Aust. J. Agric. Res.* **13**, 335.

كمية مياه الشرب كقياس لحجم الماء فى الجسم فى الأبقار

ممدوح كامل شبيطة والكسندر فاو
كلية الزراعة ـ الفيوم

استخدم فى هذا البحث ستة عجول فريزين عند وزن ٥٦٢ كيلو جرام وحقنت بالماء المشع تحت درجة حرارة ١٦° م و٦٠٪ رطوبة نسبية وذلك للمقارنة بين حساب كمية الماء الكلى فى الجسم باستخدام الطريقة المطولة عن طريق أخذ عينات من الدم أو البول والطريقة المختصرة عن طريق أخذ عينات من الدم • لذلك فقد تم أخذ ١٢ عينة دم فى الفترة مذ ٢ الى ١٩٢ ساعة بعد الحقن بالماء المشع • وقد تم جمع البول يوميا فى الفترة من ٢٤ ـ ١٩٢ ساعة بعد الحقن بجانب هذا فان كمية مياه الشرب كانت تقدر يوميا لمدة ٨ أيام •

وقد أسفرت النتائج بأنه لا يوجد أى اختلاف معنوى فى حساب كمية الماء الكلى فى الجسم اذا كانت العينات مأخوذة من الدم أو من البول ولكن وجد اختلاف معنوى على مستوى ٠٥ر بين عينات البول والدم عند حساب نصف العمر البيولوجى للماء فى الجسم ومعدل استبدال الماء فى الجسم • كما أسفرت النتائج عن عدم وجود اختلاف معنوى فى حساب كمية الماء الكلى فى الجسم اذا أخذت عينة دم واحدة • بعد ٢ أو ٤ ساعة من الحقن بالمادة المشعة (الطريقة المختصرة) أو استخدام الطريقة المطولة • وعلى ذلك فانه يمكن حساب حجم الماء الكلى فى الجسم بعد ساعتين من الحقن بالمادة المشعة وبالتالى فانه يمكن حساب مكونات الجسم الحى فى الحيوان (بروتين، دهن ، رماد) بعد ساعتين من الحقن بدلا من الانتظار ٨ أيام للحصول على هذه المعلومات عند استخدام الطريقة المطولة •

وقد وجد أن هناك ارتباط معنوى موجب على مستوى ٠١ر بين كمية مياه الشرب وحجم الماء الكلى فى الجسم ومعدل استبدال الماء فى الجسم والمعادلات كالآتى :

حجم الماء فى الجسم باللتر = ٤٢٧ر٢ − ١ر٥١٩ × كمية مياه الشرب باللتر

معدل استبدال ماء الجسم باللتر/يوم = ٢٣ر٢ + ٢١٩ر × كمية مياه الشرب باللتر

وعلى ذلك فانه يمكن التنبؤ بمعدل استبدال الماء فى الجسم ونصف العمر البيولوجى للماء فى الجسم وحجم الماء الكلى فى الجسم وكذلك مكونات الجسم الحى وذلك عن طريق قياس كمية مياه الشرب للحيوان بدلا من الحقن بالمادة المشعة •

وهذا بالتالى يساعد على معرفة التغيرات اليومية فى المقاييس المذكورة •